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ABSTRACT

This curriculum guide contains nine units that provide the basic curriculum components required to develop lesson plans for the machine shop curriculum. The guide is not intended to be a complete, self-contained curriculum, but instead provides the teacher with a number of informational items related to the learning outcomes and allows the teacher flexibility to design instructional activities, select resources, and deliver instruction most appropriate for the learner and learning environment. The units of instruction contain the following components: learning outcomes; associated tasks; performance standards; lists of tools, equipment, resources, and limiting constraints; performance steps; and enabling objectives. The units cover the following topics: bench work; layout; drill press; power saw; lathe; shaper; milling machine; surface grinder; and special milling processes. (KC)

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VOCATIONAL EDUCATION CURRICULUM GUIDE

INDUSTRIAL AND TECHNICAL EDUCATION

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Program Improvement Through

C·B·V·T·E

Competency Based Education

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MACHINE SHOP

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MACHINE SHOP

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Preface

The concept of competency based vocational-technical education has been supported by the Bureau of Vocational, Technical and Adult Education for a number of years. Since the early 1970's, the State has sponored the development and dissemination of numerous competency based curricula through the State Vocational Curriculum Laboratory. With the recent development of the State Master Plan for Public Education, however, the need to move rapidly toward systemwide adoption of this instructional concept in all schools is mandated by State Board of Education Policy.

According to the State Master Plan for Public Education, all instructional programs are to be learner oriented and described in terms of high quality, measurable, student centered outcomes (learning outcomes). In essence, this policy reinforces the competency-based vocational education philosophy.

Consistent with our current efforts in encouraging the implementation of vocational education learning outcomes, we have prepared this curriculum guide to assist vocational teachers as they prepare lesson plans that are reflective of the mandated core curriculum and defensible in terms of an equitable, quality vocational program.

Additional copies of this curriculum guide may be obtained from the:

West Virginia Vocational Curriculum Laboratory
Cedar Lakes Conference Center
Ripley, West Virginia 25271
Telephone: (304) 372-7021
Toll Free: 1-800-WVA-JOBS (in state)

Any suggestions you have for improving this material may be sent to your Vocational Curriculum Laboratory. Through this feedback, we plan to continually update and revise our materials.

VOCATIONAL, TECHNICAL AND ADULT EDUCATION

Clarence E. Burdette
Assistant State Superintendent of Schools

Overview

The contents of this guide provide the basic curriculum components required to develop lesson plans that address the learning outcomes for this particular area of study. As such, this guide is not intended to be a complete, self-contained curriculum. Instead, the teacher is provided a number of informational items related to the learning outcomes and allowed the flexibility to design instructional activities, select resources and deliver instruction most appropriate for the learner and learning environment.

Specifically, this curriculum guide is organized in the following manner:

Units of Instruction (Where applicable)

A unit of instruction is a group or cluster of related learning outcomes that have been placed together for their similarity or main idea of task accomplishment. An example of a Unit would be Shielded Metal Arc Welding within the welding and cutting area of study.

Learning Outcomes

A learning outcome, oftentimes synomous with a competency statement, is a concise description of the curriculum in terms of desired learner behavior. Such statements are measurable, may contain one or more tasks and be action oriented. All approved learning outcomes for vocational education have undergone a strigent verification process with input from teachers and representatives of the business and/or industrial sector.

The approved learning outcomes for a specific vocational education area of study represent the core competencies of what has been identified as a quality vocational education experience. They do not, however, represent the entire instructional program for any area of study. It is hoped that all vocational instructors and local educational agencies will provide learners with educational experiences that exceed the "core competencies" identified through the learning outcomes.

Associated Tasks

A task represents an identifiable behavior that (1) has a purpose; (2) has a definite beginning and ending; (3) contains two or more steps none of which is a restatement of the original task statement if in the psychomotor domain; and (4) has a standard of performance which can be defined, described and verified. Learning outcome statements may be on the task level or may contain two or more independent tasks.

Examples of task/behavior statements are:

1. Chase external pipe threads.
2. Bleed diesel fuel system.
3. Use common standard medical abbreviations.
4. Prepare a resume.
5. Plan food experiences suitable for young children.

Performance Standards

The Standard is defined as criteria for assessing if tasks are performed or demonstrated as either acceptable or unacceptable. The performance standard communicates to the learner the quantity and quality of how well he or she is expected to complete the task. The standard can be stated in terms such as actual percentage of achievement, the accuracy expected, the number of errors permitted, the time allowed to complete the task, the degree, or any other appropriate level at which achievement is anticipated. The standard should be based on the performance level needed on the job.

Examples of standards are:

1. The circuit board must operate within the tolerances of the circuit design.
2. The estimate must be within + or -5% of that figured by the instructor.
3. Contacts must open when more than 125% of rated current value is made to pass through the overload relay heating element or coil.
4. The installation must be complete and each conductor must be terminated according to the schematic drawing of the design.
5. The motor must carry the load without being overloaded; the directions of rotation must be correct; belt must have a deflection of between 3/8" or 1/2".

Tools, Equipment, Resources and Situation(s)

Situation(s) is defined as the limiting constraints under which actions are to occur. The circumstances or restrictions imposed on the learner when he or she is demonstrating the behavior must be defined. Frequently, the conditions identify the testing situation used to determine learner achievement of the standard. Tools and equipment are the materials needed to perform the task being addressed in each performance standard.

Performance Steps

Performance steps are a series of steps required to perform a psychomotor task. The steps (1) are arranged in the sequence ordinarily followed on the job, (2) have a concise start and close, (3) are limited to the accompanying task statement, and

(4) are self-supporting and do not refer to actions beyond the task performance. Performance steps developed for each task are used to determine the enabling objectives and steps and procedures for performance checklist(s) to be utilized in assessing learner mastery of the task.

Enabling Objectives

Enabling objectives reflect the knowledges, attitudes and related skills the learner must possess in order to complete the task to the specified standard(s). As such, enabling objectives are derived from an instructional analysis of the task and/or performance steps and are stated in measurable terms of student performance.

Terms such as "define verbally," "construct," "diagram" and "list" are used to express enabling objectives, rather than obscure verbs like "know," "learn" and "understand". Examples of acceptable enabling objectives are:

1. List verbally the parts of a voltmeter.
2. Define Ohm's Law.
3. Explain relevant safety precautions and procedures.
4. Discriminate between types of life insurance policies.

Given this information for each outcome statement, the instructor is encouraged to develop the following components for lesson planning, delivery and evaluation.

Develop Instructional Activities

Instructional activities should be designed to provide the learner with experiences related to the enabling objectives, cumulating in successful task performance. The instructional activity section of a curriculum should contain a variety of strategies designed for the learners' varying learning styles and rates.

Consideration should be given to age, ability levels, educational levels, varied learning styles, individual interests, career goals, and emotional needs when developing the instructional activities. Activities should include suggestions for large groups, small groups and individual methods. The use of small groups may help students attain the skills, knowledge and attitudes associated with each task by making them (1) feel adequate and physically competent when they lack the necessary background information and experience; (2) feel a sense of security through the reenforcement of positive group attitudes; (3) gain confidence and discover that they are an essential part

of a team engaged in the learning-teaching process; (4) learn to work without direct supervision, and (5) vary instructional routines away from lecture or other full-class methods.

Identify Appropriate Instructional Resources

Instructional resources should be identified for each instructional activity and should be designed to help convey the message of the task and enabling objective(s). Attempts should be made to utilize modern instructional technology (i.e. television, computers, videotapes, etc.) as much as possible in delivering the message desired. However, caution is advised in limiting the suggested resource section to only one alternative; due to the differing availability of resources between like programs across the state.

Provide Instruction

Many misconceptions exist about how an individual teacher must manage the instructional process when utilizing the competency based approach. Oftentimes CBE is considered synonmous with individualized instruction, wherein the instructor becomes the instructional manager of the educational process instead of the more traditional view of the teacher. Such misconceptions have led many educators to renounce competency based education as a means by which the teacher loses control and direction over the instructional process and is relegated to merely a role of record keeper.

The underlying concept of competency based instruction, however, does not dictate specific instructional procedures and methodologies, but rather assures that those skills, knowledges and attitudes deemed essential for job success are taught, mastered to acceptable standards and documented. How this instruction is managed within the classroom, be it on a large group, small group or individualized basis should be left up to the instructor.

The content of the task itself and the enabling objectives dictate what should be taught. Thus, the instructional activities and supporting resources identified in the instructional plan must be designed to accommodate learner mastery of the subject matter. Where appropriate, this instruction may involve large group activities, smaller group participation and/or solely individualized study.

Where substantial diversity exists between ability and skill levels of the learners within a class, arrangements should be made to structure learning activities that accommodate this difference. This type of instructional arrangement is particularly crucial, given that one of the major premises of competency based instruction is that the learner be allowed to progress at his/her own pace and that this progression be based upon successful mastery of sequential competencies.

Also, another major consideration that must be given to providing competency-based instruction is the development of a mechanism whereby learners, due to prior experience or instruction, be allowed to "test out" on skills already attained without undue duplication of effort. This situation is most often addressed through the use of pretests prior to formal instruction.

*Evaluate Learner Performance

Evaluation of learner performance is one of the most critical steps in the instructional process. Criterion-referenced evaluative measures are advocated over the traditional norm-referenced approach due to the importance of all learners being able to perform to specialized standards. As such, the evaluation of learning outcomes and their related tasks should include means of assessing learner mastery of the knowledges, attitudes, and skills outlined in the enabling objectives and regarded as essential for completion of the learning outcomes/tasks, and also, learner performance of the learning outcomes/tasks to the performance standard.

In order to adequately evaluate learners, consideration must be given to constructing testing situations that address any or all of the three domains of learning encompassed within the learning outcome or task (i.e., psychomotor, cognitive, and affective).

*Note: The Bureau of Vocational, Technical and Adult Education is currently in the process or has developed comprehensive test item banks (written and performance) for a number of vocational education areas of study. For information relative to the availability of these item banks, contact the Assistant Director, Curriculum and Personnel Development.

Guide Coding System

Example: 4.2.3

4. - unit designation
2. - learning outcome under unit
3 - task under learning outcome

VOCATIONAL EDUCATION CURRICULUM GUIDE

MACHINE SHOP

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PROGRAM OF STUDY: INDUSTRIAL AND TECHNICAL EDUCATION

AREA OF STUDY: MACHINE SHOP

UNIT: 1 BENCH WORK

LEARNING OUTCOME:

1.1 Layout, cut, and file a square workpiece to precision specifications.

TASK(S):

1.1.1 Layout a square workpiece to precision specifications.
1.1.2 Cut and file a square workpiece to precision specifications.

TASK:

1.1.1 Layout a square workpiece to precision specifications.

PERFORMANCE STANDARD:

Scribed lines must be within (+ or -) 1/64" of specified dimensions.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Blueprint, compass, layout dye, layout instrument, stock

PERFORMANCE STEPS:

1. Read blueprint to determine dimensions.
2. Clean surface of stock.
3. Apply layout fluid.
4. Layout overall dimensions.
5. Locate center lines.
6. Scribe circles and arcs.
7. Scribe straight line.

ENABLING OBJECTIVES:

1. Demonstrate reading a rule.
2. Define center lines.
3. Differentiate between diameter and radius.
4. Define the term tangent.
5. Describe how to sharpen a scriber.
6. Explain converting inches to decimals.
7. Explain metric conversion.

UNIT: 1 BENCH WORK

LEARNING OUTCOME:

Layout, cut, and file a square workpiece to precision specifications.

TASK:

1.1.2 Cut and file a square workpiece to precision specifications.

PERFORMANCE STANDARD:

Filed workpiece must be within tolerance of (+ or -) 1/64" on fraction dimensions, (+ or -) 0.005" on decimal dimensions, (+ or -) 1 degree on angular dimensions and/or within blueprint specifications.

TOOLS, RESOURCES, EQUIPMENT AND SITUATIONS(S):

Assorted files, file card, file charts, file handles, hock with layout, vise

PERFORMANCE STEPS:

1. Select file.
2. Check file handle.
3. Clean file.
4. Mount workpiece.
5. Test flatness and/or angle of work.
6. Check for pinning.
7. File to final tolerance repeating steps 5 and 6 as required.

ENABLING OBJECTIVES:

1. Explain relevant safety practices and procedures.
2. Identify the various file shapes.
3. Identify the various file cuts.
4. Describe how to install a file in a handle.
5. Define the term pinning.
6. Identify cutting fluids for filing.

UNIT: 1 BENCH WORK

LEARNING OUTCOME:

1.2 Cut external and internal threads.

TASK(S):

1.2.1 Cut external threads.
1.2.2 Cut internal threads.

TASK:

1.2.1 Cut external threads.

PERFORMANCE STANDARD:

Threaded work must fit a GO NO-GO gauge and be within tolerance of (+ or -) 1/64" in length and/or meet blueprint specifications.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Standard tool kit, assorted dies, die stock, GO NO-GO, lubricant, measuring tools, thread plug gauge, work holing device

PERFORMANCE STEPS:

1. Check blueprint for size and length of thread.
2. Select die and die stock.
3. Prepare workpiece for threading.
   a. Grind or machine bevel on end.
   b. Grind or machine 0.003" to 0.005" undersize.
   c. Mount workpiece in work-holding deice.
   d. Mark off length of thread.
4. Thread workpiece with die.
   a. Use lubricant.
   b. Start on chamfered part of die.
   c. Start die square with workpiece.
   d. Check occasionally with square.
   e. Press down and turn one revolution, then back up on-half a turn.
   f. Check with gauge after a few threads are made.
   g. Adjust die, if necessary.
   h. Thread to finished length.
   i. Reverse die on workpiece and thread to shoulder if threads run to shoulder.
5. Check workpiece with GO NO-GO thread plug gauge.
6. Assure workpiece within or without specified tolerances.
   a. Approve workpiece, or
   b. Reject workpiece and/or take corrective action.

ENABLING OBJECTIVES:

1. Explain relevant safety practices and procedures.
2. Differentiate between taps and dies.
3. Define term split die.

4. Describe a chamfer or bevel.
5. Differentiate between following terms: SAE-NC; SAE-NF; pipe thread, metric thread, ACME thread, right hand thread, and left hand thread.
6. Identify cutting lubricants and their applications.

UNIT: 1 BENCH WORK

LEARNING OUTCOME:

1.2 Cut external and internal threads.

TASK:

1.2.2 Cut internal threads.

PERFORMANCE STANDARD:

Tapped workpiece must fit gauge or mating screw, be within a tolerance of (+ or -) 1/64 and/or meet blueprint specifications.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Standard tool kit, drill press and bits, lubricant, taps and tap wrench, thread gauge

PERFORMANCE STEPS:

1. Secure workpiece in work-holding device.
2. Locate hole position and center punch.
3. Select tap drill and drill hole.
   a. Consult reference tables.
   b. Clamp work in work-holding device.
4. Select tap and wrench.
   a. Use caution in selection of size of wrench.
   b. Clamp tap in holder.
   c. Select taper tap.
5. Tap hole.
   a. Use lubricant, as required.
   b. Deburr hole (countersink to thread depth).
   c. Start tap in hole.
   d. Check alignment with square.
   e. Turn one full turn clockwise (RH threads).
   f. Back up slightly to break chips.
   g. Tap hole through and clean out hole.

   NOTE: For blind hole, clean out more than once.
6. Verify tapped hole with gauge or mating screw and with blueprint specifications.

ENABLING OBJECTIVES:

1. Explain relevant safety practices and procedures.
2. Differentiate between taps and dies.
3. Describe deburring procedure.
4. Identify cutting lubricants and their applications.
5. Differentiate between following terms: SAE-NC; SAE-NF; pipe thread, metric thread, ACME thread, right hand thread, and left hand thread.
6. Identify taper, plug, and bottom tap.
7. Describe a blind hole.

UNIT: 1 BENCH WORK

LEARNING OUTCOME:

1.3 Broach an internal keyway.

TASK:

1.3.1 Broach an internal keyway.

PERFORMANCE STANDARD:

Workpiece must be within a tolerance of (+ or -) 0.001" on decimal dimensions and (+ or -) 1/64" on fraction dimensions and/or meet blueprint specifications.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Standard tool kit, arbor press, broaching tool and guide

PERFORMANCE STEPS:

1. Clean and deburr workpiece.
2. Mount work and supports on arbor press.
3. Select broaching tool and guides.
4. Align broaching tool on workpiece.
   a. Check ram wear on arbor press.
   b. Check vertical alignment of broaching tool.
5. Press broaching tool through workpiece.
   a. Use lubricant except on cast iron.
   b. Repeat cut with shims if necessary.
6. Check measurement of workpiece.
   a. Accept workpiece, or
   b. Reject workpiece and/or take corrective action.

ENABLING OBJECTIVES:

1. Explain relevant safety practices and procedures.

2. Identify parts of arbor press.
3. Describe how arbor press functions.
4. Describe broaching tool shapes available.
5. Identify broached items.

UNIT: 1 BENCH WORK

LEARNING OUTCOME:

1.4 Scribe circles, radii, and parallel lines on a workpiece.

TASK:

1.4.1 Scribe circles, radii, and parallel lines on a workpiece.

PERFORMANCE STANDARD:

Workpiece must be layed out to a tolerance of (+ or -) 1/64" and/or blueprint specifications.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Combination square, files, hammer, layout dye, layout instruments, prick punch, scriber, stock

PERFORMANCE STEPS:

1. Deburr and clean workpiece.
2. Coat surface with layout dye.
3. Select reference surface or edge on workpiece.
   a. Check blueprint for reference edge.
   b. Use finished surface for reference on workpiece.
4. Scribe one end of workpiece.
   a. Allow room for complete layout on workpiece.
   b. Scribe perpendicular to reference edge.
5. Scribe centerlines of arcs and holes.
6. Prick punch hole locations on centerlines.
7. Scribe arcs and holes, if necessary.
8. Layout outline of workpiece.
9. Check layout against blueprint.
   a. Approve workpiece, or
   b. Correct layout by recoating workpiece with layout dye and completely layout again until all designated dimensions are within tolerance specified.

ENABLING OBJECTIVES:

1. Locate center lines.
2. Differentiate between diameter and radius.
3. Define the term tangent.
4. Demonstate converting inches to decimals.

UNIT: 1 BENCH WORK

LEARNING OUTCOME:

1.5 Remove broken bolt or tap.

TASK(S):

1.5.1 Remove broken bolt.
1.5.2 Remove broken tap.

TASK:

1.5.1 Remove broken bolt.

PERFORMANCE STANDARD:

Threaded hardware must be removed and fit of original tapped hole must be maintained.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Center punch, drill assortment, electric drill motor, personal safety equipment, screw extractors, tap wrenches, taps, wiping rags, work-holding device

PERFORMANCE STEPS:

1. Lock out equipment power.
2. Select drill.
3. Center punch in center of damaged screw or other threaded fastener.
   Note: Anneal/normalize if necessary.
4. Drill hole in center of damaged fastener.
5. Place screw extractor in hole.
6. Remove damaged screw/fastener.
7. Clean out hole.
8. Inspect threads for burrs and damage.
9. Retap if necessary.

ENABLING OBJECTIVES:

1. Explain relevant safety practices and procedures.
2. Differentiate between tempering and annealing procedures for ferrous and nonferrous metals.
3. Explain sizes of screw extractors.
4. Describe size and shape of pilot hole for screw extractors.
5. Explain thread sizes.
6. Describe how to use a tap.
7. Describe how to use a torch for annealing.

UNIT: 1 BENCH WORK

LEARNING OUTCOME:

1.5 Remove broken bolt or tap.

TASK:

1.5.2 Remove broken tap.

PERFORMANCE STANDARD:

Workpiece must have broken tools removed and meet blueprint specifications.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Drill, hammer, pliers, punches, tap extractor, tap wrench

PERFORMANCE STEPS:

1. Check blueprint for tap size.
2. Select tap extractor.
   a. Note number of flutes.
   b. Check fingers of extractor.
3. Remove broken tap.
   a. Check RH or LH threads.
   b. Remove tap if tap extends above workpiece surface.
   c. Extend fingers completely into flutes.
   d. Slide sleeve down against workpiece.
   e. Use lubricant, if necessary.
   f. Watch for fractured pieces.
   g. Work tap back and forth with removal.
   h. Use EDM machine on unremovable taps.
4. Clean out tapped hole and retap.

ENABLING OBJECTIVES:

1. Explain relevant safety practices and procedures.
2. Identify the parts of a tap.
3. Explain right and left hand threads.
4. Explain causes for taps breaking.
5. List thread forms.
6. Identify parts of EDM machine.
7. Describe how EDM machine operates.
8. Describe how to set up and operate EDM machines.

UNIT: 1 BENCH WORK

LEARNING OUTCOME:

1.6 Set up and install a bushing in a workpiece.

TASK:

1.6.1 Set up and install a bushing in a workpiece.

PERFORMANCE STANDARD:

Bushing must be installed without scratching or distorting bushing. Bushing must be installed according to specifications.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Standard tool kit, arbor press, bearing press/puller, bushing

PERFORMANCE STEPS:

1. Remove old bushing with puller.
2. Clean bore with solvent.
3. Lubricate new bushing O.D. if required.
4. Press new bushing into bore until seated.
5. Lubricate inside of bushing.

ENABLING OBJECTIVES:

1. Explain relevant safety practices and procedures.
2. Identify parts of arbor press.
3. Describe how to operate arbor press.
4. Describe function of bushing.
5. List materials used for bushings.
6. Identify cleaning solvents available.
7. Identify various lubricants and their applications.

UNIT: 1 BENCH WORK

LEARNING OUTCOME:

1.7 Clean, inspect and lubricate a pedestal grinder.

TASK:

1.7.1 Clean, inspect and lubricate a pedestal grinder.

PERFORMANCE STANDARD:

Machined/sliding/finished surfaces must be clean and free of grit and dirt. Oil level gauges must how "full." All grease fittings

and oil points must be lubricated according to manufacturer's specifications.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Standard tool kit, grease gun, manufacturer's manual, oil cans, personal safety equipment, wiping rags

PERFORMANCE STEPS:

1. Turn off/lock out grinder power.
2. Consult manufacturer's manual for lubrication specifications/ locations.
3. Disassemble as necessary.
4. Wipe clean all machined finished surfaces (ways, slides, etc.).
   a. Check for wear.
5. Locate/wipe clean lubrication points/grease fittings according to manufacturer's manual.
6. Select lubricants.
7. Fill oil reservoirs.
8. Lubricate grease fittings.
9. Check oil level gauges.
10. Wipe off excess lubricants as necessary.
    a. Check for and remove grit on sliding surfaces.
11. Reassemble as necessary.
    a. Check to see that all lines are open before assembling on systems with automatic lubrication and feed.
12. Unlock power.

ENABLING OBJECTIVES:

1. Explain relevant safety practices and procedures.
2. Identify different types of grinders.
3. Identify the parts of a pedestal grinder.
4. Explain how pedestal grinder operates.
5. Explain types of lubricants available and their applications.
6. Explain wheel grit ratings.
7. Explain ferrous and non-ferrous wheels.
8. Describe how to adjust guards and tool rest.

UNIT: 1 BENCH WORK

LEARNING OUTCOME:

1.8 Inspect, true, dress and mount grinding wheel.

TASK(S):

1.8.1 Inspect, true, and dress grinding wheel.
1.8.2 Mount grinding wheel.

TASK:

1.8.1 Inspect, true, and dress grinding wheel.

PERFORMANCE STANDARD:

Wheel must be dressed to specifications, free of glaze and loadings, valleys and ridges.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Grinder (pedestal, bench, cylindrical w/tool post/holding attachment), grinding machine manual, grinding wheel dresser (diamond tool), personal safety equipment, 6" scale, wrenches, box end, wrenches, open end

PERFORMANCE STEPS:

1. Inspect grinding wheel for damage.
   a. Ring test for cracks.
   CAUTION: DAMAGED WHEEL MUST BE REPLACED.
2. Select diamond point dresser.
3. Place dressing tool in tool post or holding attachment.
   Note: Varies with type of grinder, pedestal, bench, cylindrical.
4. Set speed of grinder at regular grinding rate.
5. Adjust depth of cut to remove glaze and loadings.
   a. Apply coolant/lubricant if necessary.
6. Stop wheel.
7. Check to specifications.
8. Start wheel.
9. Adjust depth of cut as necessary.
10. Stop wheel.
11. Check to specifications.

ENABLING OBJECTIVES:

1. Explain relevant safety practices and procedures.
2. Identify different types of grinders.
3. Identify the parts and how they function for grinding operations.
4. Differentiate between loading, glazing, valleys and ridges.
5. Describe various cutting fluids and lubricants utilized for dressing wheels.
6. Explain how to ring test wheels.
7. Explain how to maintain and care for dressing tool.

UNIT: 1 BENCH WORK

LEARNING OUTCOME:

1.8 Inspect, true, dress and, mount grinding wheel.

TASK:

1.8.2 Mount grinding wheel.

PERFORMANCE STANDARD:

Grinding wheel must be mounted according to manufacturer's specifications. Guards and tool rest must clear wheel.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Standard tool kit

PERFORMANCE STEPS:

1. Lock out power.
2. Clean spindle and surfaces of fixed flange.
3. Ring test wheel to check for damage.
4. Insert bushings.
5. Slide wheel on spindle.
   Note: Do not force wheel.
6. Clean outer flange and slide up against wheel.
7. Check to see if flanges bear uniformly against wheel.
8. Tighten spindle nut against outer flange
   Note: See manufacture torquing specifications.
9. Align guards and tighten in place.
10. Stand to one side and start grinder.
    a. Allow to operate at full speed for one minute.

ENABLING OBJECTIVES:

1. Explain relevant safety practices and procedures.
2. Describe types of wheels and their applications.
3. Identify how to true and dress wheel.
4. Identify types of grinders.
5. Describe how to balance wheel.

UNIT: 1 BENCH WORK

LEARNING OUTCOME:

1.9 Adjust wheel guard and tool rest.

TASK:

1.9.1 Adjust wheel guard and tool rest.

PERFORMANCE STANDARD:

Wheel guards must not rub against wheels. Tool rest must be aligned to center line of wheel according to manufacturer's specifications.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Standard tool kit, manufacturer's manual

PERFORMANCE STEPS:

1. Lock out power.
2. Loosen all fasteners holding guard.
3. Position according to manufacturer's specifications.
4. Tight fasteners to specifications.
5. Loosen tool rest.
6. Align to center line of wheel and position approximately 1/16 inch from wheel.
7. Tighten tool rest bolts.
8. Stand to one side and turn on power.
   a. Allow to run to full speed.
   b. Shut off.
9. Double check to see that all bolts are tight.

ENABLING OBJECTIVES:

1. Explain relevant safety practices and procedures.
2. Identify testing wheels for damage.
3. Identify types of grinders.
4. Describe types of grinding wheels manufactured.
5. Describe how to true and dress grinding wheels.

UNIT: 1 BENCH WORK

LEARNING OUTCOME:

1.10 Hand grind a center punch and chisel.

TASK:

1.10.1 Hand grind a center punch and a chisel.

PERFORMANCE STANDARD:

Ground tools must be within tolerance of (+ or -) 3 degree on angular dimensions and (+ or - 1/64" on fraction dimensions.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Standard tool kit, grinder, tools to be sharpened, wheel dresser

PERFORMANCE STEPS:

1. Inspect grinding wheel and replace cracked wheel.
2. Dress, if required
   CAUTION: WEAR GOGGLES.
3. Adjust work rest within 1/16" of wheel.
4. See that guards are in place.
5. Start grinder.
6. Grind tool.
   a. Grind flat surface.
      (1) Hold tool at right angles to wheel face.
      (2) Hold down on work rest with one hand.
      (3) Guide tool across wheel with other hand.
      (4) Move tool across face of wheel.
      (5) Continue cuts until tool face ground square.
      (6) Finish grind on fine wheel.
   b. Grind angular surfaces.
      (1) Set work rest at or near required angle and within 1/8" of wheel face.
      (2) Hold tool on work rest with one hand.
      (3) Start grinder.
      (4) Move tool with other hand across wheel face.
      (5) Check angle with protractor.
      (6) Adjust work rest as required.
      (7) Grind tool following steps 2-7 until tool ground within tolerance.
   c. Grind point.
      (1) With one hand hold tool against work rest at required angle.
         (a) Included angle of center punch is 90 degrees.
         (b) Included angle of prick punch is 30 degrees.
      (2) Bring tool against wheel with other hand.
         (a) Rotate tool with fingers.
         (b) Move tool across face of wheel.
      (3) Check angle with protractor.
      (4) Change angle if necessary and grind until tool is required angle.
7. Inspect and measure tool.
   a. Accept tool, or
   b. Reject tool and/or take corrective action.

ENABLING OBJECTIVES:

1. Explain relevant safety practices and procedures.
2. Explain using the Machinist Handbook to determine shape and specifications for tool being sharpened.
3. Identify various types of grinders and how they function.
4. Identify various types and grits of wheels for grinders.
5. Explain temper and annealing.
6. Identify various types and grades of honing stones.
7. Describe testing and dressing grinding wheels.

UNIT: 1 BENCH WORK

LEARNING OUTCOME:

1.11 Hand grind concave or convex radius on tool bit.

TASK:

1.11.1 Hand grind concave or convex radius on tool bit.

PERFORMANCE STANDARD:

Sharpened tool bit will meet specifications for cutting application. (See Machinists Handbook).

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Grinder, Machinist's Handbook, tool

PERFORMANCE STEPS:

1. Check specifications.
2. Rough shape tool on grinder by moving tool back and forth across grinding wheel.
3. Quench when needed to prevent over heating bit.
4. Check angles with gauges.
5. Finish cut with light pressure rotating tool bit to obtain desired radius.
6. Quench when needed to prevent over heating bit.
7. Check radius with gauge.
8. Hone tool bit on honing stone.

ENABLING OBJECTIVES:

1. Explain relevant safety practices and procedures.
2. Identify shapes of tools as found in Machinist's Handbook.
3. Describe type of material used for cutter bits.
4. Define the term relief angle.
5. Identify parts of grinder.
6. Describe how to true and dress a grinding wheel.
7. Describe the relationship of wheel diameter and spindle speed.

UNIT: 2 LAYOUT

LEARNING OUTCOME:

2.1 Layout hole spacing, outside dimensions, angles, bolt circles and angle tangent to radius on a workpiece.

TASK:

2.1.1 Layout hole spacing, outside dimensions, angles, bolt circles and angle tangent to radius on a workpiece.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Blueprint, layout dye, layout instruments, stock for layout

PERFORMANCE STEPS:

1. Deburr and clean workpiece.
2. Coat surfaces with layout dye.
3. Select reference surface or edge on workpiece.
   a. Check blueprint for reference edge.
4. Scribe perpendicular to reference edge.
5. Scribe center lines of arc and holes.
6. Prick punch hole locations on center lines.
7. Scribe arcs and holes, if necessary.
8. Layout outline of workpiece.
9. Check layout against blueprint.

ENABLING OBJECTIVES:

1. Differentiate between diameter and radius.
2. Define the term tangent.
3. Describe how to sharpen scribe.
4. Explain converting inches to decimals.
5. Explain metric conversions.

UNIT: 3 DRILL PRESS

LEARNING OUTCOME:

3.1 Clean, inspect, and lubricate drill press.

TASK:

3.1.1 Clean, inspect, and lubricate drill press.

PERFORMANCE STANDARD:

Oil reservoirs must be full and all grease fittings must be greased/lubricated in accordance with manufacturer's specifications.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Grease gun, manufacturer's manual, oil can, personal safety equipment, screw drivers, wiping rags, wrench, open/box end

PERFORMANCE STEPS:

1. Lock out drill press power.
2. Consult manufacturer's manual to determine lubrication specifications and locations.
3. Wipe clean oil points.
4. Wipe clean grease fittings.
5. Check condition of grease fittings.
   a. Replace if necessary.
6. Clean machine surface/T-slots.
7. Check oil level gauges where existent.
   a. Check for leaks.
8. Fill oil reservoirs according to manufacturer's specifications.
9. Re-check oil level gauges.
10. Lubricate grease fittings according to specifications.
11. Lightly oil machined surfaces.
12. Wipe off excess lubricants.
13. Unlock power.

ENABLING OBJECTIVES:

1. Explain relevant safety practices and procedures.
2. Identify the parts of a drill press.
3. Describe how a drill press operates.
4. Identify lubrication points from drawings.
5. Describe type of lubricants and their application.
6. Identify solvents that can be utilized on machined surfaces.
7. Differentiate between cast iron and forged parts on a drill press.

UNIT: 3 DRILL PRESS

LEARNING OUTCOME:

3.2 Hand and machine sharpen drills.

TASK(S):

3.2.1 Hand sharpen drills.
3.2.2 Machine sharpen drills.

TASK:

3.2.1 Hand sharpen drills.

PERFORMANCE STANDARD:

Drill bit(s) must have sharp uniform cutting edge, free of craters, nicks or burn marks. Heel must be lower than cutting

lip. Cutting lips must be of equal length. Lip and relief angels must be within (+ or -) 15 minutes or drill grinding/relief gauges or specifications.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Allen wrench, drill angle/grinding gauge, drill relief gauge, pedestal grinder, personal safety equipment, wheel dresser, wrenches, box/open end

PERFORMANCE STEPS:

1. Identify/determine angles of drill bit.
2. Inspect wheel for damage, uneven wear, eccentricity, glaze and loading.
3. Dress wheel if necessary.
4. Adjust tool rest, if necessary, to 1/8" from grinding wheel.
5. Start grinder (wheel rotation).
6. Sharpen drill bit.
   CAUTION: DO NOT ALLOW LOCALIZED HEATING.
7. Check drill bit to specifications.
8. Turn off grinder.
9. Test drill by drilling hole.
   a. Check chip formation and hole size.

ENABLING OBJECTIVES:

1. Explain relevant safety practices and procedures.
2. Explain how to dress grinding wheel.
3. Describe techniques for cooling drill point while grinding.
4. Identify parts of drill bit.
5. Describe drill bit cutting action.
6. Identify variations of relief angle for cutting special material.
7. Identify parts of drill press.
8. Describe how drill press operates.
9. Describe how to calculate spindle speed of drill press.

UNIT: 3 DRILL PRESS

LEARNING OUTCOME:

3.2 Hand and machine sharpen drills.

TASK:

3.2.2 Machine sharpen drills.

PERFORMANCE STANDARD:

Drill bit(s) must have sharp uniform cutting edge, free of craters, nicks or burn marks. Heel must be lower than cutting lip. Cutting lips must be of equal length. Lip and relief angles must be within (+ or -) 15 minutes of drill grinding/relief gauges or specifications.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Drills, drill grinding attachment, drill point gauge, drill press, drill sharpening manual, grinder, hole gauge, micrometer

PERFORMANCE STEPS:

1. Dress and true grinding wheel
   CAUTION: WEAR GOGGLES.
2. Follow manufacturer's manual to operate drill grinding fixture.
3. Grind lip clearance, length, and angle to specifications.
4. Check drill with drill point gauge.
5. Regrind alternately each cutting edge until drill fits drill point gauge.
6. Mount workpiece in work-holding device.
7. Drill hole in workpiece with sharpened drill.
8. Measure drilled hole.
   a. Accept sharpened drill as within specifications, or
   b. Repeat steps 2-8 until drill meets specifications.

ENABLING OBJECTIVES:

1. Explain relevant safety practices and procedures.
2. Explain how to dress grinding wheel.
3. Describe techniques for cooling drill point while grinding.
4. Identify parts of drill bit.
5. Describe drill bit cutting action.
6. Identify parts of drill press.
7. Describe how drill press operates.
8. Describe how to calculate spindle speed of drill press.

UNIT: 3 DRILL PRESS

LEARNING OUTCOME:

3.3 Center drill, drill, and ream hole in workpiece.

TASK(S):

3.3.1 Center drill, and drill hole in workpiece.
3.3.2 Ream hole in workpiece.

PERFORMANCE STANDARD:

Hole(s) must have smooth finish within accuracy of +0.005" of nominal drill size and locate within (+ or -) 0.010" of specifications.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Center punch, chuck wrench, deburring tool, drill size gauge, inside - outside dial vernier caliper, machinery's handbook or drilling speed/feed/drill tables, personal safety equipment, prick punch, scribe, set of drills, small hole gauges, table clamps or holding device

PERFORMANCE STEPS:

1. Verify workpiece material for selection of rill/speed/feed.
2. Verify specifications for size/type of hole (through or blind hole).
3. Lay out holes with scribe, prick punch.
   a. Recheck location.
4. Center punch.
5. Select/mount pilot drill in chuck.
   a. Check condition of drill.
6. Secure workpiece in holding device/clamp to table.
7. Select/set speed.
8. Pilot drill.
   a. Re-check location.
9. Stop drill press.
10. Remove pilot drill.
11. Select/mount drill in chuck.
    a. Check condition of drill.
    b. Step drill and reset speed/feed as necessary.
12. Select/set speed.
13. Final drill.
    a. Lubricate as necessary.
14. Turn off drill press.
15. Remove drill.
16. Remove workpiece.
17. Deburr as necessary.

ENABLING OBJECTIVES:

1. Explain relevant safety practices and procedures.
2. Identify parts of drill press.
3. Describe techniques for securing work to table.
4. Differentiate between drilling, boring, counter boring, counter sinking, reaming and honing.
5. Identify, using Machinist Handbook, the correct speed and feed rate for diameter of drill and material being machined.
6. Explain reading blueprints for layout information.
7. Describe work alignment techniques.

8. Describe how to step drill.
9. Identify lubricants and cutting fluids used for drilling on drill press.
10. Describe techniques for checking diameter and depth of drilled hole.

UNIT: 3 DRILL PRESS

LEARNING OUTCOME:

3.3 Center drill, drill, and ream hole in workpiece.

TASK:

3.3.2 Ream hole in workpiece.

PERFORMANCE STANDARD:

Hole(s) must have smooth finish and snug fit on "Go" portion of plug gauge with a Total Inch Runout (T.I.R.) of 0.0001" maximum.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Chuck wrench, drill press with accessories, Machinist's Handbook or tables for reaming sizes/speeds/feeds, personal safety equipment, plug gauge (go no-go), set of drills, set of reamers, table clamps

PERFORMANCE STEPS:

1. Identify workpiece material.
2. Set drill press speed for drilling.
3. Select holding device and accessories.
4. Secure work in holding device.
5. Align workpiece and center drill and clamp holding device.
6. Check rigidity of set up.
7. Center drill workpiece
   Note: Lubricate, as required.
8. Select drill and drill workpiece to dimensions.
   Note: Lubricate, as required.
   a. Drill undersize for reaming allowance.
   b. Check sharpness of drill.
9. Select reamer.
10. Change drill press speed to one half drilling speed.
11. Ream hole.
    a. Mount reamer in drill press (in chuck or spindle).
    b. Use lubricant as required.
    c. Feed through workpiece.
    d. Clean and deburr hole.

12. Measure hole.
    a. Accept workpiece as within specified tolerance, or
    b. Reject workpiece.

ENABLING OBJECTIVES:

1. Explain relevant safety practices and procedures.
2. Identify parts of drill press.
3. Explain techniques for securing workpiece.
4. Explain how to drill, bore and counterbore on drill press.
5. Define the term run out.
6. Identify how to set and read telescoping micrometer.
7. Describe techniques for measuring internal diameters.
8. Identify coolants/cutting fluids for reaming.
9. Identify calculating spindle speed of drill press.
10. Identify nomenclature of a ream.
11. Describe the cutting action of a ream.

UNIT: 3 DRILL PRESS

LEARNING OUTCOME:

3.4 Bore and counterbore hole in workpiece.

TASK:

3.4.1 Bore and counterbore hole in workpiece.

PERFORMANCE STANDARD:

Size, depth and concentricity of the counterbore must be within specifications.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Counterbores, drill press with accessories. holding device, Machinist's Handbook or table for selecting counterbore/speeds/ feed, personal safety equipment, rule depth gauge, table clamps, workpiece (with pilot hole)

PERFORMANCE STEPS:

1. Verify material, if necessary, for counterbore selection, cutting speed and feed.
2. Select/mount counterbore to fit pilot hole.
3. Secure workpiece in holding device and clamp to table.
4. Align counterbore with pilot hole in workpiece.
5. Select/set speed control/start drill press.
6. Counterbore hole to specified depth.
    a. Lubricate as necessary.
7. Turn off drill press.

8. Check counterbore for accuracy.
9. Remove counterbore.
10. Remove workpiece.

ENABLING OBJECTIVES:

1. Explain relevant safety practices and procedures.
2. Identify the parts of a drill press.
3. Describe techniques for securing work to table.
4. Differentiate between drilling, boring, counterboring, spot-facing, reaming and honing.
5. Identify using Machinist's handbook, the correct speed and feed rate for counterbore diameter and material being machined.
6. Describe work alignment techniques.
7. Describe how to drill pilot hole.
8. Explain how to use ruled depth gauge.
9. Describe techniques for checking counterbore diameter.
10. Identify lubricants and cutting fluids used for counter-boring.

UNIT: 3 DRILL PRESS

LEARNING OUTCOME:

3.5 Spotface workpiece.

TASK:

3.5.1 Spotface workpiece.

PERFORMANCE STANDARD:

Spotface must be smooth, free of chatter marks, true, and concentric with pilot hole according to specifications.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Drill press, depth micrometer, Machinist' handbook, spotfacing tool, steel rule

PERFORMANCE STEPS:

1. Identify workpiece material.
2. Select holding device and accessories.
3. Secure work in holding deice and check set up for rigidity.
4. Select spotface tool and pilot.
5. Mount spotfacing tool in drill press.
6. Set speed of drill (see handbook).
7. Set stop for depth.
8. Align workpiece.

9. Start drill press.
10. Spotface workpiece.
    a. Lubricate.
    b. Face to dimensions.
11. Measure spotface.
12. Readjust depth stop and recut spotface, as required to blueprint specifications.

ENABLING OBJECTIVES:

1. Explain relevant safety practices and procedures.
2. Identify pads of drill press.
3. Identify terms; drill, bore, counterbore, countersink, pilot hole, and center drill.
4. Explain how to set and read a depth micrometer.
5. Explain calculating spindle speed for drill press.
6. Identify ferrous and non-ferrous material.

UNIT: 3 DRILL PRESS

LEARNING OUTCOME:

3.6 Countersink hole in workpiece.

TASK:

3.6.1 Countersink hole in workpiece.

PERFORMANCE STANDARD:

Surface must be smooth and free from burrs and chatter marks, and concentric with hole in accordance with specifications.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Countersinks, drill press with accessories, holding device, Machinist's handbook, personal safety equipment, table clamps

PERFORMANCE STEPS:

1. Verify workpiece material for countersink selection and cutting speeds/feeds.
2. Select/mount countersink.
3. Secure workpiece in holding device/clamp to table.
4. Align countersink with hole in workpiece.
5. Select/set speed.
6. Start drill press.
7. Countersink hole.
    a. Lubricate as necessary.
8. Turn off drill press.
9. Check countersink in accordance with specifications.

10. Remove countersink.
11. Remove workpiece.

ENABLING OBJECTIVES:

1. Explain relevant safety practices and procedures.
2. Identify parts of drill press.
3. Describe techniques for securing work to table.
4. Differentiate between drilling, boring, counterboring, countersinking, reaming and honing.
5. Identify using Machinist Handbook, the correct speed and feed rate for countersinking the material being machined.
6. Describe work alignment techniques.
7. Describe how to drill hole on drill press.
8. Explain how to check countersink size with specifications.
9. Identify lubricants and cutting fluids used for countersinking.

UNIT: 3 DRILL PRESS

LEARNING OUTCOME:

3.7 Hand and power tap hole in workpiece.

TASK(S):

3.7.1 Hand tap hole and drill press.
3.7.2 Power tap hole on drill press.

PERFORMANCE STANDARD:

Threads must be at specified depth, free of burrs and chatter marks, and fit Go No-Go thread gauge within specifications.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Allen wrench, holding device, Machinist's handbook, personal safety equipment, table clamps, tap and tapping chuck, thread gauges (Go No-Go)

PERFORMANCE STEPS:

1. Select tap drill and tap as specified on blueprint (refer to Machinist's Handbook).
2. Mount workpiece in drill press vise.
3. Mount drill press vise on drill press table.
4. Mount and align combination drill and countersink to workpiece.
5. Select and set drill press speed.
6. Set depth stop on drill press.
7. Center drill workpiece.

8. Drill workpiece with tap drill.
9. Mount tap in tap wrench and align to drilled hole.
10. Mount dead center in drill chuck and align to tap center.
11. Hand tap hole to specifications using lubricant.
12. Check tapped hole with GO-NO-GO thread plug gage after cleaning chips out of hole.
    a. Accept workpiece as within tolerances, or
    b. Reject workpiece.

ENABLING OBJECTIVES;

1. Explain relevant safety practices and procedures.
2. Differentiate national course and national fines series threads.
3. Identify taper, bottom, and plug tap.
4. Describe term blind hole.
5. Identify cutting fluids and their applications.
6. Differentiate between ferrous and non-ferrous material.
7. Identify how drill press operates.
8. Describe how to power tap on drill press.

UNIT: 3 DRILL PRESS

LEARNING OUTCOME:

3.7 Hand and powertap holes in workpiece.

TASK:

3.7.2 Power tap hole on drill press.

PERFORMANCE STANDARD:

Threads must be at specified depth, free of burrs and chatter marks, and fit Go No-Go thread gauge within specifications.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Combination drill countersink, drill press, Go No-Go gauges, tapping attachment, taps, work-holding device

PERFORMANCE STEPS:

1. Mount workpiece in work-holding device.
2. Select tap drill and tap.
3. Mount center drill in drill press.
4. Secure workpiece to drill press table aligned with center drill.
5. Set speed and feed.
6. Center drill, then drill hole.
7. Mount and secure tapping attachment.

8. Tap hole to specifications.
    a. Mount tap in collet.
    b. Check operator's manual for tapping attachment operation.
    c. Set drill press speed.
    d. Set drill press stop when required.
    e. Allow tap to complete cut to full depth before retracting from hole.
9. Clean tapped hole and check with Go No-Go gauge.
    a. Accept workpiece as within specifications, or
    b. Reject workpiece.

ENABLING OBJECTIVES:

1. Explain relevant safety practices and procedures.
2. Differentiate between national course and national fine series threads.
3. Identify taper, bottom and plug tap.
4. Describe term blind hole.
5. Identify cutting fluids and their application.
6. Differentiate between ferrous and non-ferrous material.
7. Identify parts of drill press.

UNIT: 4 POWER SAW

LEARNING OUTCOME:

4.1 Clean, inspect, and lubricate vertical an/or horizontal band saw and power hacksaws.

TASK:

4.1.1 Clean, inspect, and lubricate vertical and/or horizontal band saw and power hacksaws.

PERFORMANCE STANDARD:

Saw must be lubricated according to manufacturer's specifications. Blade must be tensioned and aligned according to specifications and guards must be in place and operable.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Standard tool kit, brush, cleaning solvent, lubricants, manufacturer's manual, rags

PERFORMANCE STEPS:

1. Clean off all chips with brush.
2. Clean oil and dirt from saw.
3. Lubricate saw (check manufacturer's specifications).
    a. Apply grease to fittings.

b. Apply oil to oil cups.
c. Oil slides lightly.

4. Inspect saw.
   a. Check tension on blade.
   b. Check vertical alignment of blade.
   c. Check blade for sharpness and damage.
   d. Mount inserts and adjust to tolerance with feeler gauge.
5. Verify adjustments with short test run.
   a. Approve saw adjustments, or
   b. Reject saw adjustments and adjust to specifications.

ENABLING OBJECTIVES:

1. Explain relevant safety practices and procedures.
2. Identify various types of power saws.
3. Identify types of lubricants and their applications.
4. Define the function of the lubricant.
5. Identify cutting oil/coolants used with power saws.
6. Identify blade applications from tooth configuration.
7. Describe operation of various power saws.

UNIT: 4 POWER SAW

LEARNING OUTCOME:

4.2 Select, cut, weld and install band saw and power hacksaw blades.

TASK(S):

4.2.1 Select, cut, and weld band saw blades.
4.2.2 Install band saw and power saw blades.

TASK:

4.2.1 Select, cut, and weld bandsaw blades.

PERFORMANCE STANDARD:

Blade selected must meet job requirements. Blade must be straight, annealed, and without flash.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Band saw blade, band saw butt welder, grinder, tin snips, reference material

PERFORMANCE STEPS:

1. Cut off electrical power to saw.
2. Remove blade tension.

3. Cut blade.
4. Grind blade ends square.
5. Insert blades in welder jaws.
   a. Point teeth in.
   b. Butt ends.
   c. Center in gap.
   d. Clamp.
6. Set pressure and weld.
   CAUTION: WEAR GOGGLES.
7. Loosen clamps and set for annealing.
8. Clamp and anneal (dull red color).
9. Remove from welder jaws.
10. Grind off flash from weld.
    CAUTION: DO NOT "DISH" GRIND WELD.
    CAUTION: DO NOT GRIND SAW TEETH.
11. Check blade in thickness gauge.
12. Remount blade and adjust tension.
13. Test run blade.
    a. Accept welded blade, or
    b. Reject welded blade and make required adjustments.

ENABLING OBJECTIVES:

1. Explain relevant safety practices and procedures.
2. Identify types of saw blades and their application.
3. Identify the parts of a metal cutting band saw.
4. Explain how to operate metal cutting band saw.
5. Define the term spot weld.
6. Identify the parts of a butt welder.
7. Describe the annealing process.
8. Define the term flash.
9. Describe how to test tension on blade.

UNIT: 4 POWER SAW

LEARNING OUTCOME:

4.2 Select, cut, weld and install band saw and power hacksaw blades.

TASK:

4.2.2 Install band saw and power saw blades.

PERFORMANCE STANDARD:

Saw blades must be aligned and adjusted to operator's manual specifications.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Standard tool kit, band saw, operator's manual, power hacksaw, saw blade

PERFORMANCE STEPS:

Power Hacksaw

1. Select saw blade.
2. Cut off electrical power.
3. Release tension clamp.
4. Remove and store old blade.
5. Adjust for length of new blade.
6. Insert new blade in frame.
7. Insure that teeth point in direction of cut to be done.
8. Tighten blade in the frame.

Metal Band Saw

1. Select saw blade.
2. Cut off electrical power.
3. Release tension on blade.
4. Remove blade.
5. Loop blade for storage.
6. Check guides and remove and install new guides according to operator's manual.
7. Unwind new blade.
8. Install new blade.
9. Apply tension to blade according to operator's manual and inspect for blade direction and guide seating.

ENABLING OBJECTIVES:

1. Explain relevant safety practices and procedures.
2. Identify types of saw blades and their application.
3. Identify the parts of a metal cutting band saw.
4. Explain how to operate metal cutting band saw.
5. Identify the limitation of a power hacksaw.
6. Identify the direction the teeth should point for normal operation.
7. Demonstrate technique for looping blade for storage.

UNIT: 4 POWER SAW

LEARNING OUTCOME:

4.3 Lay out and saw an angle and a contour in a workpiece using a vertical band saw.

TASK:

4.3.1 Lay out and saw an angle and a contour in a workpiece using a vertical band saw.

PERFORMANCE STANDARD:

Workpiece must be sawed within 1/32" of scribed lines.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Band saw, band saw blades, layed out workpiece, work-holding device

PERFORMANCE STEPS:

1. Ensure that scribed lines are clear.
2. Mount and align machine guide (as required).
3. Ensure that correct blade is on saw; make necessary corrections.
4. Determine and set cutting speed.
5. Adjust and clamp saw guide.
6. Secure work in work-holding device, (as required).
7. Perform sawing operation.
   a. Support workpiece, as required.
   b. Align scribed line to blade.
   c. Advance workpiece into saw with steady pressure.
   d. Saw to specifications (1/32" from line on waste side).
   e. Note any sharp curves.

ENABLING OBJECTIVES:

1. Explain relevant safety practices and procedures.
2. Identify type of blades and their application.
3. Describe how to tension blades.
4. Identify various types of band saws.
5. Explain how to layout contoured lines.
6. Identify cutting fluids available and their application.
7. Identify characteristics of ferrous and non-ferrous metal.
8. Explain calculating cutting speed.

UNIT: 4 POWER SAW

LEARNING OUTCOME:

4.4 Lay out and saw an internal section in a workpiece using a vertical band saw.

TASK:

4.4.1 Lay out and saw an internal section in a workpiece using a vertical band saw.

PERFORMANCE STANDARD:

Internal cut on workpiece must be within 1/32" of scribed line to tolerance of (+ or -) 1/64".

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Standard tool kit, blade butt welder, blueprint, drill press and bits, vertical bandsaw

PERFORMANCE STEPS:

1. Apply layout fluid.
2. Lay out according to blueprint.
3. Check workpiece for sharp internal curves.
4. Check minimum radius limit of blade.
5. Center punch hole for inserting blade.
   a. Hole must be larger than blade width.
   b. Mark holes for sharp curves.
6. Drill hole(s) in workpiece.
7. Remove blade from band saw.
8. Cut band saw blade (near original weld).
9. Insert blade through drilled hole in workpiece.
10. Weld bandsaw blade.
    a. Grind ends square.
    b. Weld.
    c. Anneal.
    d. Grind off flash.
11. Mount blade on band saw and adjust tension.
    a. Point teeth down.
    b. Check vertical alignment.
12. Saw workpiece internally.
    a. Stay 1/32" from layout line.
    b. Check radius of cuts for arcs or curves.
13. Turn off band saw and remove blade and workpiece.
14. Cut blade (cut off original weld).
15. Remove from work and reweld blade.
16. Replace blade on band saw and adjust tension and alignment.

ENABLING OBJECTIVES:

1. Explain relevant safety practices and procedures.
2. Explain how to operate drill press.
3. Describe how to cut and weld band saw blades.
4. Describe how to mount band saw blade.
5. Identify how to test blade tension.
6. Define the terms flash and anneal.

7. Identify ferrous and non-ferrous metal.
8. Identify types of blades for band saw.

UNIT: 4 POWER SAW

LEARNING OUTCOME:

4.5 Lay out and saw straight cut and angular cut in a workpiece.

TASK(S):

4.5.1 Lay out and saw straight cut in a workpiece.
4.5.2 Lay out and saw an angular cut in a workpiece.

TASK:

4.5.1 Lay out and saw straight cut in a workpiece.

PERFORMANCE STANDARD:

Cut in workpiece must be within (+ or -) 1/32" of scribed line.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Band saw and blade, blue print, layout dye, layout instruments, square

PERFORMANCE STEPS:

1. Apply layout fluid.
2. Lay out workpiece according to blueprint.
3. Mount and align machine guide (as required).
4. Ensure that correct blade is on saw.
5. Determine and set cutting speed.
6. Adjust and clamp saw guide.
7. Secure work in work-holding device (as required).
8. Perform sawing operation.
   a. Support workpiece as required.
   b. Align scribed line to workpiece.
   c. Advance workpiece into saw with steady pressure.
   d. Saw to specifications (1/32 from line on work side).
   e. Deburr workpiece if necessary.

ENABLING OBJECTIVES:

1. Explain relevant safety practices and procedures.
2. Identify parts of metal cutting band saw.
3. Identify cutting fluids and their applications.
4. Describe test blade tension.
5. Explain causes of blade distortion.
6. Explain causes of blade binding.

UNIT: 4 POWER SAW

LEARNING OUTCOME:

4.5 Lay out and saw straight, cut and angular cut in a workpiece.

TASK:

4.5.2 Lay out and saw an angular cut in a workpiece.

PERFORMANCE STANDARD:

Cut in workpiece must be within (+ or -) 1/32" of scribed line at angle specified (+ or -) 1/2 degree.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Band saw and blade, blueprints, layout dye, layout instruments, protractor/bevel gauge

PERFORMANCE STEPS:

1. Coat workpiece with layout dye.
2. Scribe lines according to blueprint.
3. Mount and align machine guide (as required).
4. Insure that correct blade is on saw.
5. Determine and set cutting speed.
6. Secure work in work-holding device at angle specified.
7. Perform sawing operation.
   a. Support workpiece, as required.
   b. Align scribed line to blade.
   c. Advance workpiece into saw with steady pressure.
   d. Saw to specifications (1/31" from line on waste side).

ENABLING OBJECTIVES:

1. Explain relevant safety practices and procedures.
2. Explain reading a rule.
3. Identify the parts of a metal cutting band saw.
4. Identify layout instruments.
5. Describe how to test blade tension.
6. Explain how to set protractor head.

UNIT: 5 LATHE

LEARNING OUTCOME:

5.1 Clean, inspect and lubricate lathe.

TASK:

5.1.1 Clean, inspect and lubricate lathe.

PERFORMANCE STANDARD:

Lathe must be cleaned, aligned and lubricated to manufacturer's specifications.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Brush, cleaning solvent, lathe, manufacturer's manual, personal safety equipment, rags

PERFORMANCE STEPS:

1. Shut off power to lathe.
2. Clean off chips with brush.
3. Clean lathe with cleaning fluid.
4. Remove thick gum and grease with special solvent.
5. Lubricate lathe (check manual for lubricant).
   a. Check oil levels.
   b. Add oil up to index lines.
   c. Fill all small oil holes and cups.
   d. Wipe machined surfaces with thin oil film or rust inhibitor.
6. Clean coolant system if necessary.
   a. Remove chip and sediment trays and clean.
   b. Siphon out coolant reservoir and clean reservoir.
   c. Remove coolant nozzle and clean, then return.
   d. Clean coolant pump.
7. Replace coolant (check references).
8. Check coolant flow.
9. Turn on power to lathe.
10. Test run lathe for final check.

ENABLING OBJECTIVES:

1. Explain relevant safety practices and procedures.
2. Identify the parts of a lathe.
3. Describe how a lathe operates.
4. Describe use of cleaning solvents and their safety equipment.
5. Identify lubricants available for lathes.
6. Identify cutting fluids/coolants used with a lathe.
7. Explain how to read blueprint to locate lubrication points.

UNIT: 5 LATHE

LEARNING OUTCOME:

5.2 Mount independent universal and collet chucks.

TASK:

5.2.1 Mount independent universal and collet chucks.

PERFORMANCE STANDARD:

Check must be securely mounted to head stock spindle according to manufacturer's specifications.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Chucks, lathe and accessories, thread cleaner

PERFORMANCE STEPS:

Thread type spindle nose

1. Clean threads of spindle nose with thread cleaner.
2. Clean internal threads on chuck.
3. Position chuck on threads of spindle nose.
4. Screw chuck onto spindle nose until chuck tightens firmly.

Cam lock type

1. Clean spindle nose.
2. Clean internal bore of chuck.
3. Slide chuck onto spindle.
4. Turn lock screws to secure chuck to spindle.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Identify parts of lathe.
3. Identify types of chucks available.
4. Explain the advantages and disadvantages of collet chucks.
5. Explain maintenance of chuck procedures.
6. List other workholding devices for lathe turning.

UNIT: 5 LATHE

LEARNING OUTCOME:

5.3 True work in independent chuck.

TASK:

5.3.1 True work in independent chuck.

PERFORMANCE STANDARD:

Workpiece must be aligned to a tolerance of (plus or minus) 0.001 inch.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Chalk, dial indicator, four-jaw independent chuck, lathe, workpiece, wrenches

PERFORMANCE STEPS:

1. Mount workpiece in four jaw chuck using rings on face of chuck for rough alignment.
2. Center workpiece with chalk using two opposite jaws each adjustment.
   a. Mount toolholder in toolpost.
   b. Rest chalk on toolholder.
   c. Rotate workpiece holding chalk against workpiece.
3. Mount indicator on toolpost.
4. Check one pair of opposite jaws with indicator against workpiece.
5. Adjust one-half of error.
6. Check other opposite jaws and adjust one-half error.
7. Repeat steps #4-6 until workpiece within tolerance and all jaws are tightened.
8. Recommend workpiece within or without designated tolerance
   a. Accept workpiece, or
   b. Reject workpiece and/or take corrective action.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.s
2. Identify parts of four jaw independent chuck.
3. Identify shapes that require using four jaw chuck arrangement.
4. List applications of independent chuck.
5. Describe how to mount chucks to spindle.
6. Explain how to set up and use dial indicator.

UNIT: 5 LATHE

LEARNING OUTCOME:

5.4 Shape and sharpen left hand and right hand cutting tool.

TASK:

5.4.1 Shape and sharpen left hand and right hand cutting tool.

PERFORMANCE STANDARD:

Tools must be within (plus or minus 2 degrees) of angle on tool angle gage.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Angle gage, lathe tool bit, lubricant, machinist's handbook, oilstone, pedestal grinder, protractor, wheel dresser

PERFORMANCE STEPS:

1. Check references for side cutting edge angle and side relief angle required for tool bit.
2. Adjust work rest within 1/16" of wheel face.
3. Sharpen and dress grinding wheel.
   CAUTION: WEAR GOGGLES.
4. Grip one end of tool with both hands and rest left hand on work rest.
5. Hold tool at approximate cutting edge angle and tilt tool to approximate relief angle.
6. Hold tool against grinding wheel and move across face of wheel.
7. Move tool back and forth across wheel.
8. Check relief angle of toolbit in toolholder with tool angle gage.
9. Correct for any error when positioning toolbit against grinding wheel.
10. Grind until relief angle fits tool angle gage and is approximately 1/2" long for a 1/4" toolbit.
11. Check end relief angle required.
12. Grind end relief angle so it forms a 70 degree angle with side cutting edge (grind end cutting edge angle and end relief angle at same time).
13. Check end relief angle (with tool in toolholder) against tool angle gage.
14. Grind and check end relief angle until it fits gage.
15. Check side rake angle required.
16. Hold top of tool approximately 45 degrees to axis of wheel and grind side rake.
17. Grind slight radius on point of tool maintaining front and side clearance angles of finished tool.
18. Whet cutting edges on oilstone using lubricant.
19. Verify angles of tool with protractor and/or tool gage.
    a. Accept tool as within specified tolerance, or
    b. Reject tool and regrind to specifications.

ENABLING OBJECTIVES:

1. Explain relevant safety practices and procedures.
2. Identify parts of grinder.
3. Identify ferrous and non-ferrous grinding wheel.
4. Sketch the shape of the seven basic cutting tools.
5. Differentiate between end cutting edge, side relief, and end-relief and side rake angle.
6. Identify types and application of single-point cutting tool.
7. Identify the nomenclature of single point tool.

UNIT: 5 LATHE

LEARNING OUTCOME:

5.5 Center tool bit with center in tailstock.

TASK:

5.5.1 Center tool bit with center in tailstock.

PERFORMANCE STANDARD:

Tool bit cutting edge must align with point of center in tailstock spindle.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Center, cutter bit, lathe and accessories

PERFORMANCE STEPS:

1. Select center for tailstock spindle.
2. Mount cutter bit in tool holder.
3. Move tailstock or cross feed and compound rest to approximately align tool with center point tip.
4. Loosen toolholder nut screw.
5. Align cutting edge with point of center.
6. Tighten toolholder nut screw.

ENABLING OBJECTIVES:

1. Explain relevant safety practices and procedures.
2. Identify parts of lathe.
3. Describe the common cutter bit shapes and their cutting action.
4. Describe how to sharpen cutter bits.
5. Identify types of centers.
6. Explain how to grind and true centers.

UNIT: 5 LATHE

LEARNING OUTCOME:

5.6 Face, centerdrill and knurl workpiece.

TASK(S):

5.6.1 Face workpiece.
5.6.2 Centerdrill workpiece.
5.6.3 Knurl workpiece.

TASK:

5.6.1 Face workpiece.

PERFORMANCE STANDARD:

Face of workpiece must be smooth, true and square to axis of work in accordance with specifications.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Dial indicator, engine lathe with attachments and accessories, four-jaw independent chuck, lathe manual, oil can w/oil, personal safety equipment, shims, square, square cutting tool bits, three-jaw universal chuck

PERFORMANCE STEPS:

1. Identify workpiece material for selection of cutting speeds and feed.
2. Clean and lightly oil threads on lathe spindle.
   NOTE: Some lathes have cam-lock type spindle.
3. Clean threads (cam-stud) in chuck.
4. Mount chuck on lathe spindle.
5. Mount workpiece in chuck.

   Three-Jaw Universal Chuck

   a. Check and adjust for true running with shims as necessary.

   Four-Jaw Independent Chuck

   a. Adjust for true running by using dial indicator.

6. Mount cutting tool bit in toolholder.
   a. Adjust as necessary.
7. Adjust cutting tool bit to center of workpiece.
8. Lock carriage to bed.
9. Select and set speed and feed.

Small pieces

a. Hand feed

Large pieces

a. Use power cross-feed.

10. Face material to specifications.
11. Shut off lathe.
12. Remove workpiece.

ENABLING OBJECTIVES:

1. Explain relevant safety practices and procedures.
2. Identify parts of lathe.
3. Identify various styles of cutter for lathe.
4. Identify feed rate and speed using Machinist's Handbook.
5. Differentiate between ferrous and non-ferrous material.
6. Describe how to grind and hone cutter bits.
7. Explain workpiece mounting technique for four-jaw chucks, three-jaw chucks and collet chucks.
8. Identify cutting fluids and their applications.

UNIT: 5 LATHE

LEARNING OUTCOME:

5.6 Face, centerdrill and knurl workpiece.

TASK:

5.6.2 Centerdrill workpiece.

PERFORMANCE STANDARD:

Size and location of the holes must have been drilled to specifications.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Combination drill and counter sink, cutting tool bits (sharpened), drill chuck/center drillholder, engine lathe with attachments and accessories, lathe manual, Machinist's Handbook, personal safety equipment, tool post and holder

PERFORMANCE STEPS:

1. Identify workpiece material for selection of cutting speeds and feed.
2. Secure workpiece in lathe chuck.

3. Face one end of workpiece.
4. Select/mount drill chuck and combination drill/countersink in tailstock.
5. Select and set cutting speed of spindle.
6. Start lathe.
7. Drill/countersink hole to specifications.
8. Stop lathe.
9. Reverse workpiece in chuck.
10. Start lathe.
11. Face second end to length.
12. Drill/countersink second hole to specifications.
13. Stop lathe.
14. Remove workpiece.
    a. Recheck to specifications.
15. Remove drill chuck and drill from tailstock.

ENABLING OBJECTIVES:

1. Explain relevant safety practices and procedures.
2. Identify parts of lathe.
3. Identify purpose of center drilled holes.
4. Explain calculating centerdrill size.
5. Describe mounting workpiece in three-jaw and four-jaw chuck.
6. Identify technique for truing damaged center hole.
7. Sketch the shape of a spotting tool.
8. Explain cutting fluids for drilling.
9 Identify speed and rate of feed calculations.

UNIT: 5 LATHE

LEARNING OUTCOME:

5.6 Face, centerdrill and knurl workpiece.

TASK:

5.6.3 Knurl workpiece.

PERFORMANCE STANDARD:

Knurl must meet blueprint specifications and a tolerance of (plus or minus 0.015").

TOOLS, RESOURCES EQUIPMENT AND SITUATION(S):

Blueprint, cutting oil, cutting tool, lathe, knurling tool, micrometer, steel rule, toolholder, workpiece

PERFORMANCE STEPS:

1. Mount workpiece in lathe.

2. Lay off length of knurl.
3. Calculate work diameter to be knurled.
   a. Number of serrations = (21 x π) (D - 0.017")
      (D = finished diameter) (π = 3.14)
   b. O.D. = (number of serrations) x (0.015")
      (O.D. = turned diameter to be knurled)
4. Set lathe speed and feed.
5. Turn workpiece to O.D.
6. Select and mount knurling tool.
7. Position and align knurling tool.
8. Set lathe speed and feed.
   a. Speed about 1/1 rpm of turning speed.
   b. Feed about 0.020".
9. Start lathe and feed knurl into workpiece.
10. Check pattern and adjust as required.
11. Knurl workpiece.
   a. Keep feed engaged.
   b. Keep knurling tool engaged with workpiece.
   c. Reverse lathe and knurl.
   d. Use cutting oil.
12. Clean knurl and measure workpiece.
   a. Accept workpiece, or
   b. Reject workpiece and/or take corrective action.

ENABLING OBJECTIVES:

1. Explain relevant safety practices and procedures.
2. Identify parts of lathe.
3. Identify function of back gears.
4. Identify types and pitches of knurls.
5. Explain calculation for knurling serrations.
6. Identify types of knurling heads.
7. Explain calculating speeds and feed rate for knurling.
8. Define double impression.

UNIT: 5 LATHE

LEARNING OUTCOME:

5.7 Straight turn workpiece to shoulder and neck.

TASK:

5.7.1 Straight turn workpiece to shoulder and neck.

PERFORMANCE STANDARD:

Shoulder or neck cut surface must be smooth, free of marks and machined to blueprint specifications.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Lathe and attachments, micrometer, personal safety equipment, tool cutter bit

PERFORMANCE STEPS:

1. Mount chuck, face plate or center as required.
2. Mount workpiece in holding device selected.
3. Apply layout dye to workpiece.
4. Scribe measurements.
5. Select cutter bit to perform desired cut.
6. Mount cutter in toolholder on compound rest.
7. Center cutter to workpiece.
8. Calculate speed and feed.
9. Make light cut to check alignment.
10. Rough cut to slightly oversize.
11. Finish cut to specification.
12. Remove workpiece from lathe.

ENABLING OBJECTIVES:

1. Explain relevant safety practices and procedures.
2. Identify parts of lathe.
3. Describe how lathe operates.
4. Sketch the common types of shoulders.
5. Describe techniques for mounting workpiece on lathe.
6. Differentiate between a shoulder and a neck.
7. Identify cutting fluids for machining.
8. Explain sharpening and honing cutter bits.
9. Identify common cutter bits and their cutting applications.

UNIT: 5 LATHE

LEARNING OUTCOME:

5.8 Align tailstock.

TASK:

5.8.1 Align tailstock.

PERFORMANCE STANDARD:

Centers must be aligned to a tolerance of (plus or minus 0.0005").

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Center, dial indicator, lathe, test bar, wrenches

PERFORMANCE STEPS:

1. Clean centers and spindle holes.
2. Mount centers.
3. Check alignment of center in headstock.
   a. Regrind untrue hardened center.
   b. Turn untrue soft center.
4. Check index marks on tailstock.
5. Check centers together for rough alignment.
6. Mount test bar between centers.
7. Mount indicator on tool post.
8. Check indicator against test bar.
   a. Line indicator on center height
   b. Move indicator against test bar about 0.010".
9. Set indicator dial at zero at one end of test bar.
10. Check test bar with dial indicator at each end.
11. Adjust tailstock to tolerance required.

ENABLING OBJECTIVES:

1. Explain relevant safety practices and procedures.
2. Identify parts of a lathe.
3. Describe how a lathe operates.
4. Describe procedure for grinding lathe centers.
5. Explain setting up and reading dial indicator.
6. Describe procedure for making a test bar.
7. Explain why tailstock alignment is critical.
8. Explain cutting taper by tailstock offset method.

UNIT: 5 LATHE

LEARNING OUTCOME:

5.9 Drill and ream and countersink hole in workpiece.

TASK(S):

5.9.1 Drill hole in workpiece.
5.9.2 Ream hole in workpiece.
5.9.3 Countersink hole in workpiece.

TASK:

5.9.1 Drill hole in workpiece.

PERFORMANCE STANDARD:

Hole must be free of burrs and chatter marks and drilled according to specifications.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Center drill, drill holder (optional), engine lathe with attachments and accessories, headstock chuck or faceplate, lathe operator's manual, Machinist's Handbook, personal safety equipment, tailstock drill chuck or tapered shank drills, tool post, twist drill

PERFORMANCE STEPS:

1. Identify workpiece material for selection of cutting speeds/ feeds.
2. Mount workpiece in chuck or on faceplate.
3. Face workpiece as necessary.
4. Select/set speed for center drilling.
5. Select/mount drill in tailstock using chuck or taper shank drill.
6. Start lathe spindle.
7. Center drill hole by applying pressure on tailstock.
8. Stop lathe.
   a. Select/mount drill.
9. Step drill hole by repeating steps #4-8 as necessary.
   a. Lubricate as necessary.
10. Shut off lathe.
11. Check hole to specifications.
12. Remove drill/attachments.

ENABLING OBJECTIVES:

1. Explain relevant safety practices and procedures.
2. Identify cutter feed rate and speed using Machinist's Handbook.
3. Identify parts of lathe.
4. Describe mounting workpiece in three-jaw and four-jaw chuck.
5. Identify sharpening drillbit procedures.
6. Differentiate between ferrous and non-ferrous material.
7. Explain step drilling.
8. Identify cutting fluids available and their applications.

UNIT: 5 LATHE

LEARNING OUTCOME:

5.9 Drill and ream and countersink hole in workpiece.

TASK:

5.9.2 Ream hole in workpiece.

PERFORMANCE STANDARD:

Holes must be smooth, free of chatter marks and in accordance with specifications.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Centerdrill, drills, lathe and accessories, lubricants, Machinist's Handbook, plug gage, reams

PERFORMANCE STEPS:

1. Identify workpiece material and hole diameter.
2. Set lathe speed for drilling.
3. Mount workpiece in lathe.
4. Mount drill chuck and centerdrill in tailstock of lathe.
5. Set lathe speed.
6. Start lathe and face workpiece.
7. Center drill workpiece.
8. Select drill.
   a. Drill hole undersize.
   b. Step drill.
9. Select reamer.
10. Set lathe speed to one-half drilling speed.
11. Ream hole in workpiece using lubricant as required.
    a. Mount reamer in tailstock drill chuck.
    b. Feed reamer into drilled hole at moderate rate.
12. Measure hole and check with plug gauge.
    a. Approve workpiece as within specifications, or
    b. Reject workpiece.

ENABLING OBJECTIVES:

1. Explain relevant safety practices and procedures.
2. Differentiate between terms: drilling, boring, honing and counterboring.
3. Identify parts of metal lathe.
4. Identify parts of ream.
5. Identify types of reams.
6. Explain using Machinist's Handbook for calculating spindle speed.
7. Explain using inside micrometers and plug gages.
8. Explain handling and storage of reams.

UNIT: 5 LATHE

LEARNING OUTCOME:

5.9 Drill, ream and countersink hole in workpiece.

TASK:

5.9.3 Countersink hole in workpiece.

PERFORMANCE STANDARD:

Countersink hole must be within tolerance of (plus or minus 1/64") on fractional dimensions and (plus or minus 1 degree) on angular dimensions and/or within blueprint specifications.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Combination drill and countersink, countersinking tool, lathe and attachments

PERFORMANCE STEPS:

Using Countersink Cutter

1. Chuck workpiece in lathe.
2. Select and set lathe speed.
   a. Repeat in steps #3-6, as needed.
3. Face and square workpiece.
4. Centerdrill workpiece.
5. Drill workpiece.
6. Countersink to blueprint specifications.
   a. Use lubricant as required.
   b. Reduce speed.
   c. Set stop as required.
   d. Check measurements during operation.

Using Lathe Cutter Bit

1. Follow steps #1-5 under countersink cutter.
2. Set compound rest angle.
3. Mount cutter on center in toolholder.
4. Feed tool with compound rest.
5. Check angle and reset if necessary.
6. Countersink to blueprint specifications.
   a. Use lubricant as required.
   b. Reduce speed.
   c. Set stop as required.
   d. Check measurements during operation.

ENABLING OBJECTIVES:

1. Explain relevant safety practices and procedures.
2. Identify the parts of a lathe.
3. Explain how to drill, bore and counterbore.
4. Identify purpose of countersink.
5. Identify parts of countersink cutter.
6. Explain calculating spindle speed.

7. Describe grinding and shaping cutter bit.

UNIT: 5 LATHE

LEARNING OUTCOME:

5.10 Tap hole in workpiece.

TASK:

5.10.1 Tap hole in workpiece.

PERFORMANCE STANDARD:

Tapped hole must meet blueprint specifications and fit GO-NO-GO thread plug gauge.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Center drills, cutting oil, drill bits, lathe and attachments, taps, tap wrench

PERFORMANCE STEPS:

1. Mount workpiece in lathe.
2. Face and square workpiece.
3. Centerdrill workpiece.
4. Drill hole with tap drill.
5. Chamfer hole.
6. Select and secure taper tap and tap wrench.
7. Mount center in tailstock.
8. Start tap in hole.
   Note: Hold tailstock center against end of tap.
9. Tap hole in workpiece.
   a. Apply lubricant.
   b. Back tap occasionally to break chips.
   c. Clean out chips.
10. Tap with plug and bottom taps.
11. Clean out tapped hole.
12. Measure hole with GO and NO-GO gage.
    a. Accept workpiece as within specifications, or
    b. Reject workpiece.

ENABLING OBJECTIVES:

1. Explain relevant safety practices and procedures.
2. Identify the terms: SAE-NC, SAE-NF, pipe and metric thread.
3. Identify the parts of the lathe.
4. Explain taper, plug and bottom taps.
5. Explain how to drill and bore holes on lathe.
6. Identify cutting fluids for tapping.

7. Define the term chamfer.
8. Describe procedure for power tapping on lathe.
9. Explain term threads per inch.
10. Identify the nomenclature of threads.

UNIT: 5 LATHE

LEARNING OUTCOME:

5.11 Freehand form workpiece.

TASK:

5.11.1 Freehand form workpiece.

PERFORMANCE STANDARD:

Radius must be within a tolerance of (plus or minus 1/64") on fraction dimensions, fit a radius gage and/or be in accordance with blueprint specifications.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Lathe and attachments, layout die, radius gage, tool bits

PERFORMANCE STEPS:

1. Mount workpiece in lathe and set speed.
2. Check blueprint for size and location of radius.
3. Layout radius location on workpiece.
4. Mount tool and holder on compound rest.
   a. Center tool on compound rest.
   b. Locate point of tool required radius from center of compound swivel point.
5. Locate carriage and lock (refer to location of radius).
6. Loosen compound rest bolts enough so compound rest will swivel.
7. Start lathe.
8. Advance tool with cross feed.
9. Touch tool against workpiece.
10. Swing compound rest and tool in direction of cut.
11. Return to start of arc and advance tool with cross feed approximately 0.020".
12. Swing compound rest slowly by hand for second cut.
13. Stop lathe and check radius with gauge.
14. Adjust tool and carriage, if necessary.
15. Continue light cuts until radius completed.

ENABLING OBJECTIVES:

1. Explain relevant safety practices and procedures.
2. Identify parts of lathe.
3. Identify shapes of cutter bits and their cutting applications.
4. Describe sharpening procedures for cutter bits.
5. Identify cutting fluids and their applications.
6. Explain calculating spindle speed.

UNIT: 5 LATHES

LEARNING OUTCOME:

5.12 Form cut workpiece with forming tool.

TASK:

5.12.1 Form cut workpiece with forming tool.

PERFORMANCE STANDARD:

Workpiece formed surface must be smooth,free of chatter marks and machined to blueprint specifications.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Formed cutter bit, lathe and accessories, layout die, Machinist's Handbook, personal safety equipment

PERFORMANCE STEPS:

1. Mount chuck, faceplate or centers as required.
2. Mount workpiece in holding device selected.
3. Apply layout dye to workpiece.
4. Scribe measurements.
5. Select cutter (or grind cutter to form).
6. Mount cutter bit in toolholder.
7. Center cutter to workpiece.
8. Calculate speed and feed.
9. Make light cut to check alignment.
10. Feed cutter into workpiece.
    a. Reduce speed if chattering occurs.
11. Finish cut to specification reducing speeds.
12. Remove workpiece from lathe.

ENABLING OBJECTIVES:

1. Explain relevant safety practices and procedures.
2. Identify parts of the lathe.
3. Describe how lathe operates.

4. Identify how to grind cutter bits.
5. Explain how to calculate speed and feed rates.
6. List advantages of form cutting.
7. Identify cutting fluids and their application.
8. Define the terms: chatter marks and burn marks.
9. Describe a gooseneck tool.

UNIT: 5 LATHE

LEARNING OUTCOME:

5.13 Bore and counterbore hole in workpiece.

TASK:

5.13.1 Bore and counterbore hole in workpiece.

PERFORMANCE STANDARD:

Hole must have smooth finish free of chatter marks and depth must be within (plus or minus 1/64"), diameter within (plus or minus 0.003") and location within (plus or minus 0.010").

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Adjustable wrench, boring bar and holder, cutting tools (sharpened), engine lathe with attachments and accessories, lathe manual, Machinist's Handbook, micrometer, personal safety equipment, steel scale, telescope gauges

PERFORMANCE STEPS:

1. Chuck workpiece in lathe.
2. Select and set lathe speed.
   a. Repeat in steps #3-12, as needed.
3. Face and square workpiece.
4. Centerdrill workpiece.
5. Step drill workpiece to within 1/8" of bore diameter.
6. Select boring bar (large as possible).
7. Select boring tool.
   a. Check for sharpness.
   b. Check for clearance.
8. Mount boring bar with tool on center height.
9. Start lathe.
10. Move tool to workpiece and take light cut.
    a. Note end of cut on boring bar.
    b. Leave tool at cross slide setting when removing from cut.
11. Measure bored hole.
12. Take additional cuts until bored to designated dimension. (Note cross feed readings are reverse of turning outside diameter).

ENABLING OBJECTIVES:

1. Explain relevant safety practices and procedures.
2. Identify parts of lathe.
3. Differentiate between terms boring and counterboring.
4. Describe drilling holes on lathe.
5. Describe mounting workpiece in universal three-jaw chuck and four-jaw independent chuck.
6. Identify sharpening bore cutter procedure.
7. Identify cutter feed rate and speed using Machinist's Handbook.
8. Differentiate between ferrous and non-ferrous material.

UNIT: 5 LATHE

LEARNING OUTCOME:

5.14 Part off workpiece.

TASK:

5.14.1 Part off workpiece.

PERFORMANCE STANDARD:

Surfaces of finished workpiece must be smooth, free of chatter marks and burrs, and cut to specifications.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Cut-off or parting tool bit and cut-off blade holder, cutting tool bit, engine lathe with attachments and accessories, file, lathe manual, Machinist's Handbook, micrometer, personal safety equipment, scale, tool holder

PERFORMANCE STEPS:

1. Identify the metal stock for selection of cutting speed and feed.
2. Mount stock in chuck.
3. Face and square stock.
4. Mount and secure cut-off tool bit.
5. Select and set cutting speed for spindle.
6. Select and set feed rate on power cross-feed.
7. Make light parting cut and check length.
8. Cut workpieces to specifications.
   a. Deburr as necessary.
9. Check measurements to specifications.
10. Remove stock.

ENABLING OBJECTIVES:

1. Explain relevant safety practices and procedures.
2. Identify parts of the lathe.
3. Identify sharpening and honing parting tool.
4. Identify feed rate and spindle speed using Machinist's Handbook.
5. Explain deburring procedure.
6. Identify cutting fluids and their applications.
7. Describe turning between center techniques.
8. Describe mounting workpiece in collet chuck and three-jaw chuck.

UNIT: 5 LATHE

LEARNING OUTCOME:

5.15 Machine external and internal O-ring grooves.

TASK(S):

5.15.1 Machine external O-ring grooves.
5.15.2 Machine internal O-ring grooves.

TASK:

5.15.1 Machine external O-ring grooves.

PERFORMANCE STANDARD:

Groove surface must be smooth, free of chatter marks and machined to blueprint specifications.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Caliper (outside), knife edge vernier, lathe and accessories, personal safety equipment, roundnose grooving cutter bit

PERFORMANCE STEPS:

1. Select and mount holding devices to lathe.
2. Mount workpiece in lathe.
3. Grind tool bit to size and shape of groove.
4. Mount tool bit in toolholder and set cutting tool height to center of workpiece.
5. Layout location of groove on workpiece.
6. Set lathe for approximately one-half the speed for turning.
7. Start lathe and carefully bring cutting tool against workpiece until it lightly marks the diameter.
8. Note reading on graduated collar of cross-feed screw handles.
9. Calculate depth of groove by subtracting the groove diameter

from working diameter and divide this amount by two.
Note: This indicates amount tool bit must be fed to cut groove to required depth.

10. Feed grooving tool into work slowly by turning cross-feed handle.
11. Reduce spindle speed if chatter occurs.
12. Continue to turn cross-feed handle until graduated collar indicates required depth.
13. Stop lathe and check groove diameter with caliper or knife edge vernier.
14. Remove workpiece.

ENABLING OBJECTIVES:

1. Explain relevant safety practices and procedures.
2. Identify parts of the lathe.
3. Describe how to grind tool bit.
4. Identify cutting fluids for turning.
5. Explain calculating spindle speed.
6. Identify ferrous and non-ferrous materials.

UNIT: 5 LATHE

LEARNING OUTCOME:

5.15 Machine external and internal O-ring grooves.

TASK:

5.15.2 Machine internal O-ring grooves.

PERFORMANCE STANDARD:

Groove surface must be smooth, free of chatter marks and machined to blueprint specifications.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Boring bar, caliper (inside), lathe and accessories, personal safety equipment, round nose grooving cutter.

PERFORMANCE STEPS:

1. Mount chuck to lathe.
2. Mount workpiece in chuck.
3. Grind tool bit to size and shape of groove.
4. Bore inside diameter to specifications.
   a. Step drill as necessary.
5. Mount O-ring cutter bit in boring bar head and set cutting tool height to center of workpiece.
6. Layout location of groove on workpiece.

7. Set lathe for approximately one-half the speed for turning.
8. Start lathe and carefully bring cutting tool against workpiece until it lightly marks the diameter.
9. Note reading on graduated collar of cross-feed screw handle.
10. Calculate depth of groove.
11. Feed grooving tool into work slowly by turning cross-feed handle.
12. Reduce spindle speed if chatter occurs.
13. Continue to turn cross-feed handle until graduated collar indicates required depth.
14. Stop lathe and check groove diameter with caliper.
15. Remove workpiece.

ENABLING OBJECTIVES:

1. Explain relevant safety practices and procedures.
2. Identify parts of the lathe.
3. Describe how to grind tool bit.
4. Identify cutting fluids for turning.
5. Explain calculating spindle speed.
6. Identify ferrous and non-ferrous material.

UNIT: 5 LATHE

LEARNING OUTCOME:

5.16 Machine external angle with compound.

TASK:

5.16.1 Machine external angle with compound.

PERFORMANCE STANDARD:

Taper surface must be smooth, free of chatter marks and cut according to specifications.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Cutting tool, dial indicator, drill chuck, drills, engine lathe with attachments and accessories, lathe manual, Machinist's Handbook, micrometer, personal safety equipment, taper gage, vernier bevel protractor

PERFORMANCE STEPS:

1. Identify material of workpiece for selection of cutting speeds and feed.
2. Chuck workpiece on lathe.
3. Select and set speed for facing.
4. Face workpiece and center drill.

5. Reverse ends of workpiece face to length and center drill.
6. Mount workpiece between centers.
7. Set compound rest to specifications with dial indicator and vernier bevel protractor.
8. Mount, adjust and secure cutting tool.
9. Make rough cut.
10. Measure workpiece and adjust cutting tool and compound rest as necessary.
11. Select and set spindle for finish cuts.
12. Finish cut to specifications.

ENABLING OBJECTIVES:

1. Explain relevant safety practices and procedures.
2. Identify parts of lathe.
3. Identify cutter bits and their cutting applications.
4. Identify feed rate and spindle speed using Machinist's Handbook.
5. Describe how to grind and hone cutter bits.
6. Explain how to convert taper into degree for setting compound rest.
7. Explain workpiece mounting techniques for four-jaw chucks, three-jaw chucks and collet chucks.
8. Identify cutting fluids and their applications.
9. Describe other techniques for cutting external tapers; taper attachment and offsetting-tail.

UNIT: 5 LATHE

LEARNING OUTCOME:

5.17 Machine external taper using taper attachment.

TASK:

5.17.1 Machine external taper using taper attachment.

PERFORMANCE STANDARD:

Taper surface must be smooth, free of chatter marks and cut according to specifications.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Dial indicator, lathe and attachments, Machinist's handbook, micrometer, personal safety equipment, taper gauge

PERFORMANCE STEPS:

1. Chuck workpiece on lathe.
2. Select and set speed (repeat in steps 3-7 as needed).

3. Face and center drill workpiece.
4. Secure workpiece between centers.
5. Set taper attachment.
   a. Position taper attachment allowing for length of taper and clamp.
   b. Set attachment for taper required (see print and/or calculate).
   c. Position tool on center height of workpiece.
   d. Engage feed 12" before start of cut (for backlash).
6. Make roughing cut.
7. Measure workpiece and make required adjustments.
8. Check workpiece with GO and NO GO gauge.
9. Finish cut to specifications.

ENABLING OBJECTIVES:

1. Explain relevant safety practices and procedures.
2. Identify parts of lathe.
3. Identify cutter bits and thin cutting applications.
4. Identify feed rate and spindle speed using Machinist Handbook.
5. Describe how to grind and hone cutter bits.
6. Explain how to convert taper into degree of a setting taper attachment.
7. Explain workpiece mounting techniques for four-jaw chucks, three-jaw chucks and collet chucks.
8. Identify cutting fluids and their applications.
9. Describe other techniques for cutting external tapers.

UNIT: 5 LATHE

LEARNING OUTCOME:

5.18 Machine internal tapered surface.

TASK:

5.18.1 Machine internal tapered surface.

PERFORMANCE STANDARD:

Taper surface must be machined according to blueprint specifications.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Boring bar with tool, dial indicator, drills, internal micrometer, lathe and attachments, Machinist's Handbook, plug gauge

PERFORMANCE STEPS:

1. Calculate taper for taper attachment from references.
2. Chuck workpiece in lathe.
3. True workpiece with dial indicator.
4. Select and set speeds (repeat in steps 4-10), as necessary.
5. Center drill workpiece.
6. Step drill to blueprint specifications.
7. Mount boring bar holder and boring bar with tool on compound rest.
8. Adjust lathe taper attachment.
   a. Set swivel bar.
   b. Tighten binding screw.
   c. Check cross slide.
   d. Lubricate taper attachment.
9. Position boring bar and tool to blueprint specifications.
   a. Set center height.
10. Turn taper and check for accuracy.
11. Take additional cuts, checking workpiece with prussian blue and taper plug gauge.
12. Finish cut to specifications.

ENABLING OBJECTIVES:

1. Explain relevant safety practices and procedures.
2. Identify parts of lathe.
3. Identify cutting fluids available.
4. Describe sharpening cutter bits.
5. Define the terms drill, bore, counterbore and counter sink.
6. Explain converting taper per inch to taper in degrees.
7. Explain using plug gauges.
8. Explain using compound rest for internal taper.
9. Describe mounting workpiece in three-jaw, four-jaw, and collet chucks.

UNIT: 5 LATHE

LEARNING OUTCOME:

5.19 Cut taper using tailstock offset method.

TASK:

5.19.1 Cut taper using tailstock offset method.

PERFORMANCE STANDARD:

Taper surface must be smooth, free of chatter marks, and cut according to specifications.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Dial indicator, lathe and attachments, Machinist's Handbook, micrometer, personal safety equipment, taper gauge

PERFORMANCE STEPS:

1. Mount dial indicator on compound rest of lathe.
2. Adjust carriage so dial indicator pointer touches centerline of tailstock spindle.
3. Adjust cross slide in about 0.010".
4. Set dial indicator on zero.
5. Calculate tailstock set over from blueprint dimensions.

$$\text{Offset} = \frac{L \times (D-)}{2 \times 1}$$

D = diameter at large end of taper
d = diameter at small end of taper
L = total length of workpiece
l = length of taper

6. Loosen tailstock clamp and adjust tailstock.
7. Tighten tailstock clamp and place workpiece between centers.
   a. Check lathe dog for clearance.
   b. Check and lubricate tailstock with rule.
8. Check witness marks on tailstock with rule.
9. Set lathe speed and feed.
10. Mark off length of taper.
11. Machine rough cut on taper of workpiece.
    a. Set tool on center height.
    b. Allow for adjustment and finish cut.
12. Measure diameters of workpiece at one inch interval.
13. Check taper per inch with taper required.
14. Adjust (as required).
    a. Apply prussian blue for gauge check.
    b. Make finishing cuts.
15. File and polish to specifications (check with gauge).

ENABLING OBJECTIVES:

1. Explain relevant safety practices and procedures.
2. Identify parts of lathe.
3. Identify cutter bits and their cutting applications.
4. Identify feed rate and spindle speed using Machinist's Handbook.
5. Describe how to grind and hone cutter bits.
6. Identify cutting fluids and their applications.
7. Explain converting degree of taper into taper per foot.
8. Identify other techniques for cutting external tapers.

UNIT: 5 LATHE

LEARNING OUTCOME:

5.20 Turn long shaft between centers.

TASK:

5.20.1 Turn long shaft between centers.

PERFORMANCE STANDARD:

Workpiece must be within tolerances of (+ or -) 0.005" on decimal dimensions and (+ or -) 1/64" on fraction dimensions and/or meet blueprint specifications.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Center drill, dial indicator, lathe with accessories, lubricant, Machinist's Handbook, micrometers

PERFORMANCE STEPS:

1. Mount workpiece in chuck.
2. Face and center drill ends.
3. Mount drive plate and centers on lathe.
4. Check center alignment.
   a. Adjust, as required.
5. Mount workpiece between centers with lathe dog attached.
6. Locate tailstock and adjust center.
   a. Lock both and lubricate center as required.
7. Check workpiece material.
8. Calculate and set speed.
9. Layout end of cut.
10. Mount lathe tool and holder.
    a. Set tool to swing away from workpiece.
    b. Check mounting at start of cut.
    c. Check mounting at lathe dog for clearance.
11. Set lathe feed for rough cut.
12. Start lathe and take trial cut short distance.
13. Stop lathe and measure workpiece.
14. Start lathe.
15. Adjust depth and rough cut 0.020" to 0.030" oversize.
16. Measure workpiece for taper and size.
17. Set lathe feed for finish cut.
18. Mount finishing tool.
19. Machine to designated dimension.

ENABLING OBJECTIVES:

1. Explain relevant safety practices and procedures.
2. Identify parts of lathe.

3. Explain calculating spindle speed, feed rates and depth of cut.
4. Identify cutter bit shapes.
5. Describe cutter bit sharpening procedures.
6. Identify techniques for additional supports for long shaft cutting.
7. Explain setting, using, care of, and reading micrometers.
8. Identify use and reading of dial indicators.

UNIT: 5 LATHE

LEARNING OUTCOME:

5.21 Indicate shaft in lathe using steady rest.

TASK:

5.21.1 Indicate shaft in lathe using steady rest.

PERFORMANCE STANDARD:

Shaft must be within tolerance of (+ or -) 0.005".

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Dial indicator, lathe and attachments, steady/follower rest, wrenches

PERFORMANCE STEPS:

1. Mount chuck on lathe.
2. Mount workpiece in chuck.
3. Face and center drill workpiece on each end, if possible.
4. Adjust steady rest for workpiece centered both ends.
   a. Place workpiece between centers.
   b. Locate steady rest and clamp to bed (check carriage location).
   c. Raise two lower jaws to touch work and finger tighten clamping bolt.
   d. Apply lubricant and lower the upper jaw to work allowing slight clearance.
   e. Lock all three jaws.
   f. Adjust upperjaw during machining for expansion of work-piece.
   g. Use soft shims with jaws for machined surface.
5. Adjust steady rest for workpiece without center hole.
   a. Chuck one end of workpiece (lightly).
   b. Position steady rest near outer end of workpiece.
   c. Scribe two cross center lines using centerhead.
   d. Prick punch intersection of two lines.
   e. Place dead center in tailstock.

f. Move dead center up to punch mark.
g. Adjust lower jaws to steady rest and lock.
h. Tighten chuck.
i. Locate steady rest and clamp to bed of lathe.
(1) Check carriage location.
j. Adjust upper jaw, lubricate and lock.

ENABLING OBJECTIVES:

1. Explain safety practices and procedures.
2. Identify parts of lathe.
3. Explain how lathe operates.
4. Explain setting up and reading dial indicators.
5. Describe purpose and function of steady rest and followers.

UNIT: 5 LATHE

LEARNING OUTCOME:

5.22 Chase external and internal right hand and left hand unified threads.

TASK(S):

5.22.1 Chase external right hand and left hand unified threads.
5.22.2 Chase internal right hand and left hand unified threads.

TASK:

5.22.1 Chase external right hand and left hand unified threads.

PERFORMANCE STANDARD:

Threads must be free of burrs and cut to specifications.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Engine lathe with attachments, lathe manual, Machinist's Handbook, micrometer, personal safety equipment, thread center gauge, tool cutting bits (ground to proper thread form)

PERFORMANCE STEPS:

1. Chuck workpiece in lathe.
2. Select and set speed.
   a. Repeat in steps 3-12, as needed.
3. Face and center drill workpiece.
4. Secure workpiece between centers.
5. Set compound rest to thread specifications (29 degrees or 30 degrees).
6. Mount and align cutter tool bit with gauge.

7. Set gear box and headstock gears.
8. Set lathe speed (slow).
9. Check movement of threading tool for length of work.
10. Start lathe.
11. Make thread dial selection.
12. Cut threads to specifications.
    a. Check pitch after first light cut.
    b. File burrs during threading operation.
    c. Use lubricant.
    d. Finish with light cuts.
    e. Check fit before completion of cuts.
13. Measure thread with GO and NO GO thread ring gauge.
    a. Accept workpiece, or
    b. Reject workpiece.

ENABLING OBJECTIVES:

1. Explain relevant safety practices and procedures.
2. Identify parts of lathe.
3. Differentiate between various thread configuration, SAE-NC, SAE-NF, metric, pipe, ACME, square drive.
4. Identify calculating cutting speed and feed rate using Machinist's Handbook.
5. Identify sharpening cutter bit procedure.
6. Describe using die cutters on lathe.
7. Identify ferrous and non-ferrous material.
8. Explain rechasing threads.

UNIT: 5 LATHE

LEARNING OUTCOME:

5.22 Chase external and internal right hand and left hand unified threads.

TASK:

5.22.2 Chase internal right hand and left hand unified threads.

PERFORMANCE STANDARD:

Threads must be free of burrs and cut to specifications.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Boring bar, engine lathe with attachments and accessories, lathe manual, Machinist's handbook, personal safety equipment, scale, thread plug gauges, tool bit ground to thread form

PERFORMANCE STEPS:

1. Identify material of workpiece for selection of drills, cutting speeds and feed.
2. Chuck workpiece in lathe.
3. Face workpiece.
4. Center-drill workpiece.
5. Step-drill as necessary.
   a. Lubricate as necessary.
6. Bore hole to minor diameter of threads.
7. Set compound rest to specifications.
8. Mount and square boring bar using center gauge.
9. Set up quick-change gear box.
10. Make thread dial selection.
11. Turn on lathe.
12. Cut threads to specifications.
13. Turn off lathe.
14. Check threads with thread plug gauge.
15. Remove workpiece.
16. Remove tool bit.

ENABLING OBJECTIVES:

1. Explain relevant safety practices and procedures.
2. Identify parts of lathe.
3. List limitation of cutting internal threads with boring bar.
4. Differentiate between various thread configurations, SAE-NC, SAE-NF, metric, pipe, ACME, square drive.
5. Identify calculating cutting speeds and feed rate using Machinist's Handbook.
6. Explain sharpening cutter bit.
7. Explain rechasing threads.
8. Describe hand tapping on lathe.
9. Identify ferrous and non-ferrous material.

UNIT: 5 LATHE

LEARNING OUTCOME:

5.23 Pick up lead on external unified threads.

TASK:

5.23.1 Pick up lead on external unified threads.

PERFORMANCE STANDARD:

Threads must be free of burrs and cut to specifications.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Lathe and attachments, personal safety equipment, thread cutter bit, thread micrometer

PERFORMANCE STEPS:

1. Mount workpiece in lathe.
2. Mount and align threading tool.
   a. Set compound rest on 29 degrees or 30 degrees.
   b. Use center gauge for alignment.
3. Set lathe gear box and gears on headstock.
   a. Check blueprint for thread size.
   b. Check for RH or LH threads.
4. Set lathe speed slow.
5. Start lathe.
6. Engage half nut and stop lathe after carriage moves a short distance (leave half nut engaged).
7. Adjust cross feed and compound rest until tool matches thread.
8. Set cross feed dial and compound rest dial to zero.
9. Disengage half nut and move tool to start of thread.
10. Take finishing cuts until thread cut to designated dimension.
11. Check thread with GO and NO-GO thread ring gauge.
    a. Accept workpiece, or
    b. Reject workpiece and/or take corrective action.

ENABLING OBJECTIVES:

1. Explain relevant safety practices and procedures.
2. Identify parts of lathe.
3. Differentiate various thread configurations, SAE-NC, SAE-NF, metric, ACME, pipe, unified.
4. Identify calculating cutting speed and feed rate using Machinist's Handbook.
5. Identify sharpening cutter bit procedure.
6. Describe using die cutters on lathe.
7. Identify ferrous and non-ferrous material.

UNIT: 5 LATHE

LEARNING OUTCOME:

5.24 Chase external and internal ACME threads.

TASK:

5.24.1 Chase external and internal ACME threads.

PERFORMANCE STANDARD:

Threads must meet blueprint specifications and class 2G fit.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

ACME ring gauge, ACME tool gauge, lathe with accessories, Machinist's Handbook

PERFORMANCE STEPS:

1. Mount workpiece between centers (with lathe dog attached).
2. Check blueprint for thread specifications.
3. Machine outside diameter of workpiece to required size.
4. Mount and align threading tool with thread gauge (set compound rest on 14 1/2 degrees).
5. Set gears on headstock and gearbox for thread.
6. Start lathe and take scratch cut.
7. Measure threads/inch.
8. Set cross slide on zero and advance compound rest 0.005".
9. Check Machinist's Handbook for thread depth or use formula:

$$TD = \frac{\text{pitch}}{2} + 0.010"$$

10. Cut threads to specifications.
    a. With cross slide on zero advance compound rest for cuts.
    b. Use cutting oil.
    c. Avoid chatter.
    d. Advance cross slide for cutting last 0.006".

ENABLING OBJECTIVES:

1. Explain relevant safety practices and procedures.
2. Identify parts of lathe.
3. Differentiate between various thread configurations, SAE-NC, SAE-NF, metric, pipe, ACME, square drive.
4. Identify calculating cutting speed and feed rate using Machinist's handbook.
5. Identify sharpening cutter bit procedure.
6. Describe using die cutters on lathe.
7. Identify ferrous and non-ferrous material.
8. Explain rechasing threads.

UNIT: 5 LATHE

LEARNING OUTCOME:

5.25 Chase external pipe threads.

TASK:

5.25.1 Chase external pipe threads.

PERFORMANCE STANDARD:

Threads must be free of burrs and cut to specifications.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Engine lathe with attachments, lathe manual, Machinist's Handbook, micrometer, personal safety equipment, thread center gauge, tool cutting bit (ground to specified thread form)

PERFORMANCE STEPS:

1. Chuck workpiece in lathe.
2. Select and set speed.
   a. Repeat in steps 3-12, as needed.
3. Face and center drill workpiece.
4. Secure workpiece between centers.
5. Set compound rest to thread specifications (29 degrees or 30 degrees).
6. Mount and align cutter tool bit with gauge.
7. Set gear box and headstock gears.
8. Set lathe speed (slow).
9. Check movement of threading tool for length of work.
10. Start lathe.
11. Make thread dial selection.
12. Cut threads to specifications.
    a. Check pitch after first light cut.
    b. File burrs during threading operation.
    c. Use lubricant.
    d. Finish with light cuts.
    e. Check fit before completion of cuts.
13. Measure thread with GO and NO-GO thread ring gauge.
    a. Accept workpiece, or
    b. Reject workpiece.

ENABLING OBJECTIVES:

1. Explain relevant safety practices and procedures.
2. Identify parts of lathe.
3. Differentiate between various thread configurations, SAE-NC, SAE-NF, metric, pipe, ACME, square drive.
4. Identify calculating cutting speed and feed rate using Machinist's Handbook.
5. Identify sharpening cutter bit procedure.
6. Describe using die cutters on lathe.
7. Identify ferrous and non-ferrous material.
8. Explain rechasing threads.

UNIT: 5 LATHE

LEARNING OUTCOME:

5.26 Turn an eccentric.

TASK(S):

5.26.1 Turn an eccentric where all centers located on workpiece.
5.26.2 Turn an eccentric where centers are too close to enable center drill without overlap.
5.26.3 Turn an eccentric for large throw.

TASK:

5.26.1 Turn an eccentric where all centers located on workpiece.

PERFORMANCE STANDARD:

Eccentric surfaces must be smooth, free of chatter marks, and machined to blueprint specifications.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Standard tool kit, blueprint, drill press and accessories, lathe and accessories, layout dye, personal safety equipment, v-block and surface plate, workpiece

PERFORMANCE STEPS:

1. Determine rough diameter of stock - to throw add one half of each eccentric diameter plus 1/8" for machining.
2. Mount workpiece in chuck.
3. Face both ends of workpiece.
   Note: Workpiece should correct length.
4. Apply lay out dye to both ends.
5. Mound workpiece in V-block on surface plate.
6. Set vernier height gauge to top of workpiece.
7. Subtract one-half the diameter of workpiece from reading in step 6 and set height gauge to this reading.
8. Scribe centerline on each end of workpiece.
9. Rotate workpiece 90 degrees in V-block.
10. Reset height gauge by subtracting one half of the throw dimensions from height setting in step 7.
11. Scribe both ends of workpiece on centerline.
12. Reset height gauge by adding the throw dimension to height gauge setting from step 10.
13. Scribe both ends of workpiece on centerline.
14. Carefully center punch intersection of all lines.
15. Center drill both sets of center holes.
16. Mount on lathe.

a. Turn largest diameter area first.
17. Mount workpiece on offset centers and turn to eccentric required diameter.

ENABLING OBJECTIVES:

1. Explain relevant safety practices and procedures.
2. Describe how to operate drill press.
3. Describe how to operate lathe.
4. Identify ferrous and non-ferrous metal.
5. Describe types of cutter bits and how to sharpen bits.
6. Describe how to turn between centers.
7. Describe techniques for drilling center holes.
8. Explain calculating spindle speeds, feed speed, and depth of cut.

UNIT: 5 LATHE

LEARNING OUTCOME:

5.26 Turn an eccentric.

TASK:

5.26.2 Turn an eccentric where centers are too close to enable center drill without overlap.

PERFORMANCE STANDARD:

Eccentric surfaces must be smooth, free of chatter marks, and machined to blueprint specifications.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Standard tool kit, blueprint, drill press and accessories, lathe and accessories, layout dye, personal safety equipment, V-block and surface plate, workpiece

PERFORMANCE STEPS:

1. Determine rough diameter of workpiece - add radius of largest diameter plus radius of smaller plus throw.
2. Cut stock 3/4" longer than required.
3. Mount workpiece on chuck and face both ends.
4. Drill set of center holes in workpiece.
5. Turn journal area to size (larger diameter).
6. Reface both ends.
   a. Workpiece should be faced to finish length.
7. Locate centers of offset journal with V-block and vernier height gauge, and center punch.
8. Drill center holes on drill press.

9. Mount workpiece on offset centers and turn eccentric to required diameter.

ENABLING OBJECTIVES:

1. Explain relevant safety practices and procedures.
2. Describe how to operate drill press.
3. Describe how to operate lathe.
4. Identify ferrous and non-ferrous metal.
5. Describe types of cutter bits and how to sharpen bits.
6. Describe how to turn between centers.
7. Describe techniques for drilling center holes.
8. Explain calculating spindle speeds, feed speed, and depth of cut.

UNIT: 5 LATHE

LEARNING OUTCOME:

5.26 Turn an eccentric.

TASK:

5.26.3 Turn an eccentric for large throw.

PERFORMANCE STANDARD:

Eccentric surfaces must be smooth, free of chatter marks, and machined to blueprint specifications.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Standard tool kit, drill press and accessories, lathe and accessories, personal safety equipment, support blocks, workpiece

PERFORMANCE STEPS:

1. Lay out and drill center holes of journals.
2. Mount work on lathe and turn journals.
3. Lay out and drill set of centers having required throws in set of support blocks. (Both sides).
4. Bore center in support block to fit journal machined in step 2.
5. Align offset centers of both support blocks with offset section to be turned and lock in position.
6. Mount work and blocks between centers of lathe.
7. Apply counterbalance to faceplate to prevent vibration when machining, add spreaders as required.
8. Machine offset eccentric diameter to specifications.

ENABLING OBJECTIVES:

1. Explain relevant safety practices and procedures.
2. Describe how to operate drill press.
3. Describe how to operate lathe.
4. Identify ferrous and non-ferrous metal.
5. Describe types of cutter bits and how to sharpen bits.
6. Describe how to turn between centers.
7. Describe techniques for drilling center holes.
8. Explain calculating spindle speeds, feed speed, and depth of cut.
9. Explain mounting work in four jaw chuck.

UNIT: 5 LATHE

LEARNING OUTCOME:

5.27 Machine workpiece using faceplate.

TASK:

5.27.1 Machine workpiece using faceplate.

PERFORMANCE STANDARD:

Workpiece must be aligned to an accuracy of (+ or -) 0.001".
Workpiece must be machined to tolerance (+ or -) 0.001" of blueprint specifications.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Bolts/straps, chalk, clamps, dial indicator, faceplate, lathe, Machinist's Handbook, soft hammer, wrenches

PERFORMANCE STEPS:

1. Mount workpiece on faceplate.
   a. Use straps/or bolts.
   b. Use counterbalance weight if necessary.
2. Roughly line up workpiece.
   a. Tighten clamps lightly.
   b. Turn lathe by hand.
3. Adjust workpiece using chalk or toolholder end.
4. Mount indicator.
5. Adjust workpiece to required accuracy using indicator.
   a. Tap with soft hammer.
   b. Tighten workpiece securely when aligned within tolerance.
6. Mount proper cutter in tool rest, aligning with center of faceplate.
7. Calculate speed and feeds (Machinist's Handbook).
8. Machine workpiece using table feed systems to blueprint specifications.

9. Remove workpiece.

ENABLING OBJECTIVES:

1. Explain relevant safety practices and procedures.
2. Identify parts of lathe.
3. Describe how to sharpen lathe cutter bits.
4. Identify ferrous and non-ferrous metal.
5. Describe how to set up a dial indicator.
6. Explain purpose of counterbalance.
7. Explain how to read blueprint.

UNIT: 5 LATHE

LEARNING OUTCOME:

5.28 Grind external and internal diameter.

TASK:

5.28.1 Grind external and internal diameters.

PERFORMANCE STANDARD:

Ground workpiece must meet blueprint specifications with a tolerance of (+ or -) 0.005".

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Grinding wheel and dressing, lathe and accessories, micrometer, tool post grinder

PERFORMANCE STEPS:

1. Mount tool post grinder.
   a. Check wheel for cracks.
      (1) Replace if cracked.
   b. Mount wheel guard.
   c. Wear goggles.
   d. Cover v-ways with wet cloth.
   e. Dress and true grinding wheel.
2. Mount workpiece on lathe.
3. Calculate and set lathe speed (usually 80-100 rpm).
4. Set feed on lathe (0.005" to 0.007").
5. Turn on power of lathe and grinder (work should turn into grinding wheel).
6. Engage workpiece with grinder.
7. Engage longitudinal feed and grind workpiece.
8. Measure workpiece with micrometer.
9. Check for taper and adjust if necessary.
10. Continue light cuts.

11. Repeat steps 7-9 until workpiece ground to size.

ENABLING OBJECTIVES:

1. Explain relevant safety practices and procedures.
2. Identify parts of lathe.
3. Identify parts of tool post grinder.
4. Describe dressing grinding wheel.
5. Describe wheel shapes and grades available.
6. List application for grinding on lathe.
7. Identify problems arising with grinding operation and their remedies.
8. Identify cutting speeds and depth of cut calculations.

UNIT: 5 LATHE

LEARNING OUTCOME:

5.29 Prepare program, set up, and operate computerized numerical control machines.

TASK(S):

5.29.1 Prepare program for computerized numerical control machines.
5.29.2 Set up computerized numerical control machines.
5.29.3 Machine workpiece with computerized numerical control machines.

TASK:

5.29.1 Prepare program for computerized numerical control machines.

PERFORMANCE STANDARD:

Program must include minimum tool changes, return to starting point and machine surfaces to blueprint specifications.
TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Machinist's Handbook, N/C machine manual, reference material

PERFORMANCE STEPS:

1. Review blueprint.
2. Determine fixture to be used.
3. Determine sequence of operations.
   a. Determine which operations to be performed.
   b. Determine order of operations: center drill, drill, tap or ream, etc.
4. Determine tools required.

5. Establish starting and finishing point (reference).
6. Calculate dimensions not on blueprint.
7. Determine tool changes.
8. Write program.
   a. Note tool changes.
   b. Note other instructions.
9. Verify program.
   a. Plus values and minus values of (x) equals zero.
   b. Plus values and minus values of (y) equals zero.

ENABLING OBJECTIVES:

1. Identify parts of N/C lathe.
2. Describe how N/C lathe operates.
3. Identify cutter bit shapes and sharpening procedures for cutter bits.
4. Identify techniques for aligning workpiece.
5. Identify mounting accessories for lathe.
6. Explain computer language for N/C machines.
7. Explain how to trouble shoot a program.
8. Identify poor machined surface, causes and how to correct the program.

UNIT: 5 LATHE

LEARNING OUTCOME:

5.29 Prepare program, set up, and operate computerized numerical control machines.

TASK:

5.29.2 Set up computerized numerical control machines.

PERFORMANCE STANDARD:

Setup must have tool aligned to start point for program, workpiece securely mounted in holding device, and program entered into computer.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Blueprints,cutter bits, N/C lathe and accessories, N/C program, operator's manual, workpiece

PERFORMANCE STEPS:

1. Review blueprint and operator's manual.
2. Mount workpiece in work-holding device.
3. Center spindle over zero point with edge finder and dial indicator.

Note: Dial reading must be noted at this time.

4. Place tape in tape reader.
5. Mount tool in toolholder.
   a. Check amount of projection.
6. Run table clear of workpiece and set depth stop.
7. Return table to start and observe first block run on tape with table lowered.
8. Make required corrections.
9. Repeat steps 5-8 with each block and change of tool.
10. Check return to zero point after machining workpiece.
11. Verify workpiece within tolerances.
12. Make required adjustments until machined workpiece is within specifications.

ENABLING OBJECTIVES:

1. Identify parts of N/C lathe.
2. Describe how N/C lathe operates.
3. Identify cutter bit shapes and sharpening procedures for cutter bits.
4. Identify techniques for aligning workpiece.
5. Identify mounting accessories for lathe.
6. Explain computer language for N/C machines.
7. Explain how to trouble shoot a program.
8. Identify poor machined surface, causes and how to correct the program.

UNIT: 5 LATHE

LEARNING OUTCOME:

5.29 Prepare program, set up, and operate computerized numerical control machines.

TASK:

5.29.3 Machine workpiece with computerized numerical control machines.

PERFORMANCE STANDARD:

Workpiece surfaces must be smooth, free of chatter marks, and machined to blueprint specifications.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Blueprints, cutter bits, N/C lathe and accessories, N/C program, operator's manual, workpiece

PERFORMANCE STEPS:

1. Review operator's manual.
2. Review blueprint.
3. Review tool program.
4. Check tools for sharpness or damage.
5. Mount workpiece in work-holding device.
6. Mount first tool in tool holder.
7. Place tape in reader and start reader.
8. Machine workpiece.
   a. Monitor for tool changes.
   b. Monitor for depth stops changes.
   c. Monitor for start/or stop coolant.
9. Remove workpiece and deburr.
10. Verify workpiece within or without designated tolerances.
    a. Accept workpiece, or
    b. Reject workpiece and/or take corrective action.

ENABLING OBJECTIVES:

1. Identify parts of N/C lathe.
2. Describe how N/C lathe operates.
3. Identify cutter bit shapes and sharpening procedures.
4. Identify techniques for aligning workpiece.
5. Identify mounting accessories for lathe.
6. Explain computer language for N/C machines.
7. Explain how to trouble shoot a program.
8. Identify poor machined surface, causes and how to correct the program.

UNIT: 6 SHAPER

LEARNING OUTCOME:

6.1 Clean, inspect, and lubricate shaper.

TASK:

6.1.1 Clean, inspect, and lubricate shaper.

PERFORMANCE STANDARD:

Shaper must be cleaned and lubricated according to operator's manual specifications.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Brush, cleaning solvent, lubricating oil, operator's manual, rags, shaper

PERFORMANCE STEPS:

1. Turn off power.
2. Clean shaper with brush.
3. Clean shaper with rags and cleaning solvent.
4. Check operator's manual.
   a. Check visually for oil holes and cups.
5. Oil cup and holes.
6. Lubricate parts with pressure lubrication, if available.
7. Oil slides and machined surfaces,
   a. Wipe off excess.
8. Check sight glass lubrication oil levels and add when required,

ENABLING OBJECTIVES:

1. Explain relevant safety practices and procedures.
2. Identify parts of shaper.
3. Describe how a shaper operates.
4. Identify clean solvents.
5. Identify types of lubricants and their applications.
6. Identify parts requiring maintenance and adjustment.

UNIT: 6 SHAPER

LEARNING OUTCOME:

6.2 Shape and sharpen rouging and finishing tool.

TASK:

6.2.1 Shape and sharpen rouging and finishing tool.

PERFORMANCE STANDARD:

Tools must be sharpened to specifications for material being machined.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Gauges, grinder, Machinist's Handbook, tool bits

PERFORMANCE STEPS:

1. Determine material being cut.
2. Determine shape and angles required form Machist's Handbook.
3. Grind tool bit on grinder, cooling as necessary.
4. Check angles with gauge.
5. Repeat steps 3 and 4 until desired shape is obtained.
6. Lightly hone edge to remove burrs.

JECTIVES:
ENABLING OBJ
relevant safety practices and procedures.
1. Explain h how a shaper functions.
2. Describe relevant sections of Machinist's Handbook.
3. Explain h cutting requirements for various material.
4. Describe how to set protractor head.
5. Describe

SHAPER
UNIT: 6 S
TCOME:
LEARNING OUTC
n set up for shaper operations.
6.3 Perform

TASK:
orm set up for shaper operations.
6.3.1 Perfor
STANDARD:
PERFORMANCE S
feeds must be in accordance with material being
Speeds and fWork must be secure to shaper.
machined. Wo
URCES, EQUIPMENT AND SITUATION(S):
TOOLS, RESOUR
handbook, operator's manual, shaper, shaper tools
Machinist's h
STEPS:
PERFORMANCE S
and set for cutting speed.
1. Select amtify and classify material of workpiece.
   a. Identtify cutter.
   b. Identermine cutting speed using table specifications.
   c. Deteermine setting of cutting speed based on length of
   d. Deter and shaper strokes per minute.
      cut aup shaper for cutting speed following operations
   e. Set ual.
      manuaand set feed.
2. Select amtify and classify material of workpiece.
   a. Identtify cutter material.
   b. Identermine cutting speed.
   c. Deteermine depth of cut needed.
   d. Deteermine feed according to required finish.
   e. Deter feed according to operations manual.
   f. Set forkpiece to table/vise securely.
3. Mount worer in holder.
4. Set cutte travel.
5. Set ram tmanually to check clearances.
6. Operate m

ENABLING OBJECTIVES:

1. Explain relevant safety practices and procedures.
2. Explain how a shaper operates.
3. Describe techniques for attaching workpiece to table.
4. Identify various cutter bits.
5. Explain how to calculate cutter speed and fee rate.
6. Differentiate between rough and finish cuts.
7. Describe how to sharpen cutter bits.
8. Describe how to use angle blocks.
9. List shaper accessories and their applications.

UNIT: 6 SHAPER

LEARNING OUTCOME:

6.4 Shape flat and angular surfaces.

TASK(S):

6.4.1 Shape flat surfaces.
6.4.2 Shape angular surfaces.

TASK:

6.4.1 Shape flat surfaces.

PERFORMANCE STANDARD:

Workpiece must meet blueprint specifications and be within a tolerance of (+ or -) 0.005" on decimal dimensions and (+ or -) 1/64" on fraction dimensions.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Standard tool kit, layout dye, Machinist's handbook, micrometer, shaper and accessories

PERFORMANCE STEPS:

1. Lay out workpiece.
   a. Clean.
   b. Deburr.
2. Align vise with dial indicator.
3. Mount workpiece in vise on parallels.
4. Select and mount tool and toolholder.
   a. Avoid excessive overhang.
   b. Incline clapper box slightly away from direction of cut.
5. Determine and set length of stroke (L + 3/4").
6. Position ram until tool extends 1/4" beyond workpiece.
7. Determine cutting speed.

8. Set speed $N = \frac{CS \times 7}{L}$
   N = number of strokes
   CS = cutting speed
   L = length of stroke
9. Position workpiece under cutting tool.
10. Set shaper feed.
    a. Direction of cut.
    b. Feed/stroke.
11. Start shaper and lower cutting tool to work.
12. Determine depth of cut and machine workpiece.
13. Measure workpiece and continue machining workpiece to designated dimension.

ENABLING OBJECTIVES:

1. Explain relevant safety practices and procedures.
2. Explain how shaper operates.
3. Describe techniques for mounting workpiece to table.
4. Identify various cutter bits.
5. Differentiate between rough and finish cuts.
6. Describe how to sharpen cutter bit.
7. Explain how to use and read a micrometer.

UNIT: 6 SHAPER

LEARNING OUTCOME:

6.4 Shape flat and angular surfaces.

TASK:

6.4.2 Shape angular surfaces.

PERFORMANCE STANDARD:

Workpiece must meet blueprint specifications and be within a tolerance of (+ or -) 1/64" on fraction dimensions and (+ or-) 1 degrees on angular dimensions.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Standard tool kit, bevel protractor, layout dye, Machinist's Handbook, micrometer, shaper and accessories

PERFORMANCE STEPS:

1. Lay out workpiece for angle cut.
2. Align vise with dial indicator.
3. Mount workpiece in vise.

a. Lay out line parallel with top of vise and use automatic table feed/or
b. Swivel vise at required angle and use automatic table feed/or
c. Swivel tool slide to required angle

4. Select tool and tool holder.
5. Swivel clapper box 15 degrees to 20 degrees away from workpiece.
6. Mount tool and toolholder on clapper box.
7. Determine and set length of stroke (L = 3/4).
8. Position ram until tool extends 1/4" past workpiece and clamp.
9. Determine cutting speed.
10. Set speed: $N = \frac{CS \times 7}{L}$

N = number of strokes
CS = cutting speed
L = length of stroke in inches

11. Position workpiece under cutting tool and lock table.
12. Hand feed ram through one complete stroke.
    a. Check clearance of toolhead.
    b. Check position of ram.
    c. Adjust.
13. Start shaper and hand feed tool for start of cut.
14. Check position and make adjustments.
15. Complete cut and measure.
16. Continue cuts and measuring until workpiece cut to specified tolerance.

ENABLING OBJECTIVES:

1. Explain relevant safety practices and procedures.
2. Explain how a shaper operates.
3. Describe techniques for mounting workpiece.
4. Identify various cutter bits.
5. Differentiate between rough and finish cut.
6. Describe functions of swivel vise.

UNIT: 7 MILLING MACHINE

LEARNING OUTCOME:

7.1 Clean, inspect, and lubricate milling machine.

TASK:

7.1.1 Clean, inspect, and lubricate milling machine.

PERFORMANCE STANDARD:

Milling machine must be cleaned, lubricated and adjusted to manufacturer's specifications.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Brush, cleaner, lubricants, manufacturer's manual, milling machine, screw drivers, wrenches

PERFORMANCE STEPS:

1. Start milling machine.
   a. Check flow gauges.
2. Stop milling machine.
3. Turn off power.
4. Clean milling machine and coolant reservoir.
   Note: Use brush for chips.
5. Clean milling machine with rags.
6. Lubricate milling machine.
   a. Oil at regular intervals.
   b. Check frequency in operator's manual.
   c. Start at one point and proceed in an orderly method.
   d. Avoid over oiling and wipe off excess oil.
6. Check oil levels on sight gauges and add.
7. Check hand operated oiling devices and lubricate milling machine where applicable.
8. Locate, clean and fill all oil holes and pockets.
9. Check and clean/or replace filters.
10. Clean and oil all sliding surfaces.
11. Clean and oil exposed screws.
12. Check motor lubrication.
13. Lubricate driving chain.
14. Lubricate bail bearings and other places requiring grease.
15. Check table movement by hand and adjust gibs (see manual).
16. Check condition of milling machine and report any needed repairs.

ENABLING OBJECTIVES:

1. Explain relevant safety practices and procedures.
2. Identify types of milling machines.
3. Identify types, classification and kinds of milling cutters.
4. Identify cutting fluids for milling.
5. Describe how various types of milling machines operate.
6. Explain how to adjust gibs.
7. Differentiate between manual, semi-automatic and automatic operation of milling machine.
8. Identify lubricants for milling machines.

UNIT: 7 MILLING MACHINE

LEARNING OUTCOME:

7.2 Align vise on milling machine table.

TASK:

7.2.1 Align vise on milling machine table.

PERFORMANCE STANDARD:

Vise must be aligned to milling machine head within a tolerance of (+ or -) 0.001" total runout.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Standard tool kit, dial indicator, milling machine

PERFORMANCE STEPS:

1. Clean and place vise on bed.
2. Align vise by sight.
3. Fasten vise to bed with clamping bolts.
   Note: Do not tighten.
4. Locate dial indicator in mill spindle or magnetic tool holder.
5. Indicate fixed vise jaw.
   a. Use square against column before using dial indicator for perpendicular alignment.
   b. Use longitudinal feed or cross feed as required.
6. Check vise jaw at each end of jaw.
7. Tap vise one-half difference of readings for correction.
8. Repeat steps 5-7 until vise aligned.
9. Secure clamp bolts.
10. Recheck with indicator.
    a. Repeat steps 5-10 until vise is aligned if vise has moved.

ENABLING OBJECTIVES:

1. Explain relevant safety practices and procedures.
2. Identify types of milling machines.
3. Identify types, classification and kinds of milling cutters.
4. Identify cutting fluids for milling.
5. Describe how various types of milling machines operate.
6. Identify types of vises for milling machines and their applications.

UNIT: 7 MILLING MACHINE

LEARNING OUTCOME:

7.3 Set up workpiece using clamps.

TASK:

7.3.1 Set up workpiece using clamps.

PERFORMANCE STANDARD:

Workpiece must be aligned to a tolerance of (+ or -) 0.001" total indicated run out.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Blocks, cardboard, dial indicator and holder, fasteners, milling machine and accessories, parallel, soft hammer, workpiece, wrenches

PERFORMANCE STEPS:

1. Clean out slots on milling machine table.
2. Study blueprint.
   a. Note surface to be machined.
   b. Note type of cutter required.
3. Place workpiece on machine table.
   a. Use cardboard under workpiece.
   b. Center workpiece longitudinally on table.
   c. Locate workpiece according to machining operation.
4. Select clamps, blocks, and bolts.
5. Clamp workpiece down lightly in rough position.
6. Clamp indicator assembly on arbor.
7. Adjust indicator contact point toward workpiece surface.
8. Move table and workpiece next to indicator contact point.
9. Move table longitudinally.
10. Adjust workpiece to correct line up with indicator.
11. Move table and workpiece in contact with indicator contact point.
12. Adjust table against indicator about 0.010".
13. Move table longitudinally the length of the workpiece.
14. Observe total movement of indicator at each end of workpiece.
15. Adjust workpiece.
    a. Adjust workpiece one half difference of end readings.
    b. Tap lightly with soft hammer.
16. Check workpiece with indicator for runout.
17. Repeat steps 13-16 until workpiece is within designated tolerance.

ENABLING OBJECTIVES:

1. Explain relevant safety practices and procedures.
2. Identify types of milling machines.
3. Identify types, classification and kinds of milling cutters.
4. Identify cutting fluids for milling.
5. Describe how various types of milling machines operates.
6. Describe other hold down techniques for workpiece.
7. Differentiate between conventional/up milling and climb/ down milling.
8. Explain setting up and reading dial indicator.

UNIT: 7 MILLING MACHINE

LEARNING OUTCOME:

7.4 Flycut workpiece surface.

TASK:

7.4.1 Flycut workpiece surface.

PERFORMANCE STANDARD:

Workpiece must be machined to a tolerance of (+ or -) 0.003" on decimal dimensions and (+ or -) 164" on fractional dimensions and/or to blueprint specifications.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Cutting tool, dial indicator, fly cutter, micrometer caliper, milling machine and accessories, parallels, steel rule, vise

PERFORMANCE STEPS:

1. Identify workpiece material.
2. Mount and align vise using dial indicator.
3. Secure workpiece in vise.
4. Select and mount flycutter.
5. Select and set speed and feed.
6. Align cutter to workpiece, touch off, and set depth of cut.
7. Make preliminary cuts.
8. Remove workpiece, deburr, rotate workpiece 180 degrees, and secure in vise on parallels.
9. Touch off and set cutter to secondary cut depth.
10. Set depth of cut to blueprint specifications.
11. Make finish cut.
12. Measure for accuracy of cut.

ENABLING OBJECTIVES:

1. Explain relevant safety practices and procedures.
2. Identify types of milling machines.
3. Identify types, classifications and kinds of milling cutters.
4. Identify cutting fluids for milling.
5. Describe how various types of milling machines operates.
6. List advantages and disadvantages of fly cutters.
7. Identify techniques for securing workpiece to table of milling machine.
8. Explain deburring procedure.
9. Differentiate between conventional or down milling and climb or up milling.

UNIT: 7 MILLING MACHINE

LEARNING OUTCOME:

7.5 Locate center of workpiece.

TASK:

7.5.1 Locate center of workpiece.

PERFORMANCE STANDARD:

Workpiece must be located within blueprint specifications to a tolerance of (+ or -) 0.001".

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Center finder, center punched workpiece, dial indicator, milling machine and accessories

PERFORMANCE STEPS:

1. Mount work-holding device on mill table.
2. Align work-holding device with dial indicator.
3. Mount center punched workpiece in work-holding device.
4. Place center finder in spindle of mill.
5. Align center finder with center punch on workpiece.
   a. Light touch point of center finder in punch mark.
   b. Rotate spindle by hand.
   c. Check runout and adjust table.
   d. Mount dial indicator with pointer against center finder.
   e. Repeat steps b and c until table aligned within tolerance.

ENABLING OBJECTIVES:

1. Explain relevant safety practices and procedures.
2. Identify types of milling machines.
3. Identify types, classifications and kinds of milling cutters.
4. Identify cutting fluids for milling.
5. Describe how various types of milling machines operate.
6. Identify types of vises and alignment.
7. Explain workpiece layout procedure.
8. Explain reading a blueprint for location and tolerances.

UNIT: 7 MILLING MACHINE

LEARNING OUTCOME:

7.6 Align milling machine head.

TASK:

7.6.1 Align milling machine head.

PERFORMANCE STANDARD:

Head must be aligned with the table to a tolerance of (+ or -) 0.0005"

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Dial indicator and holder, milling machine and accessories, wrenches, 90 degree extension rod

PERFORMANCE STEPS:

1. Adjust head to zero graduation in both directions.
2. Clean table and center under spindle.
3. Mount dial indicator on 90 degree extension rod held in spindle holder.
4. Position indicator over front of table.
5. Carefully lower spindle until indicator button touches table.
6. Lower spindle until dial indicator registers about one half revolution and set on zero.
7. Lock spindle.
8. Rotate carefully spindle 180 degrees by hand (watch for T - slots).
9. Compare front and back readings.
10. Loose locking nuts and adjust head one-half reading difference.
11. Recheck setting and make adjustments.
12. Raise and rotate spindle 90 degrees.
13. Repeat steps 6-11.
14. Check readings in both directions.

15. Adjust and check until table is aligned with spindle to required tolerance.

ENABLING OBJECTIVES:

1. Explain relevant safety practices and procedures.
2. Identify types of milling machines.
3. Identify types, classifications and kinds of milling cutters.
4. Identify cutting fluids for milling.
5. Describe how various types of milling machines operates.
6. List types of vises for milling machines.
7. List attachments available for milling machines.

UNIT: 7 MILLING MACHINE

LEARNING OUTCOME:

7.7 Seat workpiece in vise.

TASK:

7.7.1 Seat workpiece in vise.

PERFORMANCE STANDARD:

Workpiece must be seated solidly on parallels and securely.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Dial indicator, milling machine, paper strips, parallels, soft faced hammer, wrenches

PERFORMANCE STEPS:

1. Check and lubricate machine.
2. Clean slots and mount vise to table.
3. Align vise to head.
4. Place parallels in vise with workpiece on top snug jaws of vise.
5. Tap workpiece on top with soft faced hammer.
6. Tighten vise.
7. Check with paper strips to see if work is on parallels solidly.

ENABLING OBJECTIVES:

1. Explain relevant safety practices and procedures.
2. Identify types of milling machines.
3. Identify types, classifications, and kinds of milling cutters.
4. Identify cutting fluids for milling.

5. Describe how various types of milling machines operate.
6. Identify types of vises and their applications.

UNIT: 7 MILLING MACHINE

LEARNING OUTCOME:

7.8 Mill a block of metal square.

TASK:

7.8.1 Mill a block of metal square.

PERFORMANCE STANDARD:

Workpiece must meet blueprint specifications, be square, and to a tolerance of (+ or -) 0.005" on decimal dimensions and (+ or-) 1/69 on fractional dimensions.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Dial indicator, micrometer caliper, mill cutter, milling machine and accessories, soft faced hammer, square, table vise

PERFORMANCE STEPS:

1. Identify workpiece material.
2. Mount and position vise.
   Note: Use dial indicator.
3. Select and mount cutter.
4. Select and set up speed and feed.
5. Mount and align workpiece to cutter.
6. Make first cut.
7. Turn off machine, rotate workpiece to place finished side against fixed vise jaw, and secure.
8. Make second cut to depth (allow material for opposite side).
9. Measure for accuracy and place workpiece so that second finished surface (steps 7 and 8) is on the bottom of the vise.
10. Make third cut.
11. Turn off machine, measure for accuracy, and rotate workpiece.
12. Cut remaining side to specifications.

ENABLING OBJECTIVES:

1. Explain relevant safety practices and procedures.
2. Identify types of milling machines.
3. Identify types, classifications, and kinds of milling cutters.
4. Identify cutting fluids for milling.

5. Describe how various types of milling machines operate.
6. Explain calculating speed and feeds for milling machine.
7. Identify ferrous and non-ferrous metals.
8. Differentiate between conventional or up milling and climb or down milling.
9. Explain seating workpiece in vise.
10. Identify various types of vises.
11. Explain how to set and read micrometer.
12. Describe aligning vise to milling head.

UNIT: 7 MILLING MACHINE

LEARNING OUTCOME:

7.9 Drill equally spaced holes in workpiece.

TASK:

7.9.1 Drill equally spaced holes in workpiece.

PERFORMANCE STANDARD:

Holes must be located according to blueprint specifications.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Dial indicator, drills and centerdrill, milling machine and accessories, soft faced hammer

PERFORMANCE STEPS:

1. Mount and align holding device.
   a. Use indicator.
   b. Use edgefinder.
2. Secure workpiece in holding device.
3. Mount arbor and drill chuck.
4. Align over first hole to be drilled.
5. Set machine speed (see Machinist's Handbook).
6. Center drill workpiece.
   a. Use coolant as required in drilling.
7. Drill first hole.
   a. Note depth on blueprint.
   b. Note graduated dial reading for reference in drilling similar holes.
      Note: When using power feed see Machinist's handbook for rate of feed.
8. Use mill graduated dials to step over and drill subsequent holes to specifications.
9. Measure workpiece.
   a. Check hole sizes.
   b. Check hole location.

c. Accept workpiece as within tolerances, or
d. Reject workpiece and/or take corrective action.

ENABLING OBJECTIVES:

1. Explain relevant safety practices and procedures.
2. Identify types of milling machines.
3. Identify cutting fluids for milling.
4. Describe how a milling machine operates.
5. Differentiate between boring and drilling.
6. Identify hold down techniques for milling machine.

UNIT: 7 MILLING MACHINE

LEARNING OUTCOME:

7.10 Center drill and ream hole in workpiece.

TASK(S):

7.10.1 Center drill hole in workpiece.
7.10.2 Ream hole in workpiece.

TASK:

7.10.1 Center drill hole in workpiece.

PERFORMANCE STANDARD:

Center drill hole must be to size and located within tolerances specified. Hole must have smooth finish.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Center drill, milling machine and accessories, pre-marked workpiece

PERFORMANCE STEPS:

1. Identify material for selection of cutting speeds and feeds.
2. Determine size of center drill.
3. Clamp workpiece to table or in vise.
4. Install drill chuck with center drill into spindle.
5. Turn on power.
6. Position workpiece to center drill.
7. Secure table locks.
8. Select/set spindle speed.
9. Set feed control at selected rate of feed.
10. Engage spindle.
11. Start pilot hole manually, check locations.
12. Turn on coolant/cutting fluid.

13. Engage feed.
14. Drill to desired depth.
15. Disengage feed.
16. Disengage spindle.
17. Turn off coolant.
18. Unlock table and move workpiece away from spindle.
19. Remove workpiece and check accuracy of hole.

ENABLING OBJECTIVES:

1. Explain relevant safety practices and procedures.
2. Identify types of milling machines.
3. Identify types, classifications, and kinds of milling cutters.
4. Identify cutting fluids for milling.
5. Describe how various types of milling machines operate.
6. Identify various techniques for mounting workpiece.
7. Identify purpose or function of center drilled hole.
8. Differentiate between drilling, boring, counterboring and spotfacing.
9. Explain calculating speeds and feed rates.

UNIT: 7 MILLING MACHINE

LEARNING OUTCOME:

7.10 Center drill and ream hole in workpiece.

TASK:

7.10.2 Ream hole in workpiece.

PERFORMANCE STANDARD:

Hole must have smooth finish and be within tolerance of specifications T.I.R. (total inch runout) of .0005".

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Chuck key, lead hammer or mallet, lubricant for reamer, micrometer (outside), personal safety equipment, print or specifications, set of drills (sharpened), set of reamers, telescoping gauge

PERFORMANCE STEPS:

1. Identify material for selection of cutting speeds and feed.
2. Determine size of hole to be reamed.
3. Secure workpiece in vise.
4. Select/mount drill.
5. Position workpiece hole with drill.

6. Secure table locks.
7. Remove drill.
8. Select/chuck reamer.
9. Start machine.
10. Select/set spindle speed.
11. Select/set rate of feed.
12. Engage spindle speed control.
13. Engage feed control.
    a. Lubricate as necessary.
14. Ream hole to specifications.
15. Disengage feed control.
16. Disengage spindle speed control.
17. Check reamed hole to specifications.
18. Remove workpiece.
19. Turn off milling machine.

ENABLING OBJECTIVES:

1. Explain relevant safety practices and procedures.
2. Identify types of milling machines.
3. Identify types, classifications, and kinds of milling cutters.
4. Identify cutting fluids for milling.
5. Describe how various types of milling machines operate.
6. Identify techniques for securing workpiece to table.
7. Explain drilling procedures on milling machine.
8. Identify parts of ream.
9. Describe cutting action of reamer.
10. Explain calculating speeds and feed rates for reaming.

UNIT: 7 MILLING MACHINE

LEARNING OUTCOME:

7.11 Machine an outside radius using rotary table.

TASK:

7.11.1 Machine an outside radius using rotary table.

PERFORMANCE STANDARD:

Cut radius on workpiece must meet blueprint specifications with tolerance of (+ or -) 0.005".

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Dial indicator, end mill cutter, milling machine and accessories, prepared workpiece, rotary table, T-bolts and clamps, vernier caliper

PERFORMANCE STEPS:

1. Identify material of workpiece.
2. Mount rotary table on milling machine.
3. Center spindle over rotary table using dial indictor.
4. Align and clamp workpiece to rotary table.
5. Select and mount cutter.
6. Select and se speed, feed, and depth of cut.
7. Mill primary cut.
   a. Make rough cut outside finished dimension.
   b. Allow for adjustment in radius and depth.
   c. Adjust table feed as required.
8. Measure workpiece and re-adjust mill, if necessary.
9. Check surface and tolerance of workpiece and mill to specifications.

ENABLING OBJECTIVES:

1. Explain relevant safety practices and procedures.
2. Identify types of milling machines.
3. Identify types, classifications, and kinds of milling cutters.
4. Identify cutting fluids for milling.
5. Describe how various types of milling machines operate.
6. Identify ferrous and non-ferrous material.
7. Explain mounting and alignment of rotary table.
8. Explain calculating speed for cutter.

UNIT: 7 MILLING MACHINE

LEARNING OUTCOME:

7.12 Gang and form mill workpiece.

TASK(S):

7.12.1 Gang mill workpiece.
7.12.2 Form mill workpiece.

TASK:

7.12.1 Gang mill workpiece.

PERFORMANCE STANDARD:

Surfaces must have smooth finish and be machined to blueprint specifications.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Milling cutters, milling machine and accessories, personal safety equipment, workpiece

PERFORMANCE STEPS:

1. Identify material of workpiece.
2. Mount and align work-holding device.
3. Select, mount, and secure milling cutters on arbor-use collars where necessary.
4. Secure and align workpiece in work-holding device.
5. Select and set speed and feed.
6. Touch off and set depth of cut.
7. Make preliminary cut.
8. Check and measure workpiece configuration.
9. Make cutting adjustment.
10. Cut to blueprint specifications.
    a. Use coolant as required.
11. Several passes may be required.

ENABLING OBJECTIVES:

1. Explain relevant safety practices and procedures.
2. Identify types of milling machines.
3. Identify types, classifications, and kinds of milling cutters.
4. Identify cutting fluids for milling.
5. Describe how various types of milling machines operate.
6. Describe techniques for securing work to milling machine.
7. Differentiate between form and gang milling.
8. Identify types of milling cutters that can be used for form or gang milling.

UNIT: 7 MILLING MACHINE

LEARNING OUTCOME:

7.12 Gang and form mill workpiece.

TASK:

7.12.2 Form mill workpiece.

PERFORMANCE STANDARD:

Surface must have smooth finish and be machined to blueprint specifications.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Form mill cutter, milling machine and accessories, personal safety equipment, radius gauge

PERFORMANCE STEPS:

1. Identify material of workpiece.
2. Mount and align work-holding devise.
3. Select and mount form ground milling cutter.
4. Secure and align workpiece in work-holding device.
5. Select and set speed and feed.
6. Touch off and set depth of cut allowing for finish cut.
7. Make preliminary cut.
8. Check and measure workpiece configuration.
9. Make cutting adjustments and cut to blueprint specifications.

ENABLING OBJECTIVES:

1. Explain relevant safety practices and procedures.
2. Identify types of milling machines.
3. Identify types, classifications, and kinds of milling cutters.
4. Identify cutting fluids for milling.
5. Describe how various types of milling machines operate.
6. Describe techniques for securing work to milling machine.
7. Differentiate between form and gang milling.
8. Describe technique for sharpening form cutter.

UNIT: 7 MILLING MACHINE

LEARNING OUTCOME:

7.13 Cut T-slot in workpiece.

TASK:

7.13.1 Cut T-slot in workpiece.

PERFORMANCE STANDARD:

T-slot must be machined to blueprint specifications.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

End mill cutter, milling machine and accessories, personal safety equipment, T-slot cutter

PERFORMANCE STEPS:

1. Mount workpiece in vise that has been aligned.

2. Install end mill cutter of correct diameter for vertical of T in slot in spindle.
3. Determine spindle speed and feed rate.
4. Move workpiece under cutter and raise to within 1/8" of cutter.
5. Locate the cutter where groove is to be cut.
6. Set transverse table lock.
7. Start cutter rotating and raise table to start cut.
8. Set depth of cut desired.
   a. Apply coolant if necessary.
9. Set automatic feed.
10. Repeat steps 8 and 9 until specified depth is reached.
11. Remove end mill and install T-slot cutter.
12. Align bottom of T-slot cutter with bottom of slot, set all locks except direction of feed.
13. Calculate and set cutter speed and feed.
14. Lock in automatic feed to machine T-slot.
    a. Turn on coolant system if necessary.
15. Back workpiece away from spindle and remove.

ENABLING OBJECTIVES:

1. Explain relevant safety practices and procedures.
2. Identify types of milling machine.
3. Identify cutting fluids for milling.
4. Describe how various types of milling machines operate.
5. Explain calculating spindle speed, cutter speed and feed rates for milling machine.
6. Differentiate between plain mill cutter and an end mill cutter.
7. Identify types, classifications and kinds of milling cutters.

UNIT: 7 MILLING MACHINE

LEARNING OUTCOME:

7.14 Machine woodruff keyway in workpiece.

TASK:

7.14.1 Machine woodruff keyway in workpiece.

PERFORMANCE STANDARD:

Keyway must be within a tolerance of (+ or -) 0.003" on decimal dimensions, (+ or -) 1/64" on fractional dimensions and/or meet blueprint specifications.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Dial indicator, layout dye, Machinist's Handbook, micrometer caliper, milling machine and accessories, soft hammer, square, woodruff keyset cutter

PERFORMANCE STEPS:

1. Mount vise on mill table and align with dial indicator.
2. Mount workpiece in vise.
3. Select and mount keyseat cutter.
4. Set speed of machine.
5. Start machine.
6. Move table until cutter touches paper feeler on workpiece.
7. Adjust table and move table one-half diameter of workpiece plus one-half thickness of cutter.
8. Lock saddle.
9. Scribe line on workpiece indicating center of keyway.
10. Move work lengthwise to locate center line of workpiece under center of cutter.
11. Lock table.
12. Start machine and raise table by bumping vertical feed crank until cut on workpiece is width of cutter (on vertical mill move crossfeed).
13. Set elevation dial on zero.
14. Calculate depth of keyway.
15. Feed to depth of cut by hand.
16. Stop machine and lower table.
17. Deburr workpiece.
18. Tap woodruff key in keyseat and measure with micrometer caliper.

    Note: Check Machinist's Handbook for required dimension.
    a. Accept workpiece, or
    b. Reject workpiece and/or take corrective action.

ENABLING OBJECTIVES:

1. Explain relevant safety practices and procedures.
2. Identify types of milling machines.
3. Identify types, classifications and kinds of milling cutters.
4. Identify cutting fluids for milling.
5. Describe how various types of milling machines operate.
6. Identify function of woodruff key.
7. Explain setup and reading dial indicators.
8. Explain setting and reading micrometer caliper.
9. Describe table, vise and milling head alignment.
10. Explain calculation of speeds and feeds for milling machine.

UNIT: 7 MILLING MACHINE

LEARNING OUTCOME:

7.15 Machine inside radius using rotary table.

TASK:

7.15.1 Machine inside radius using rotary table.

PERFORMANCE STANDARD:

Milled surfaces must be smooth, free of chatter marks and machined to blueprint specifications.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

End mill, milling machine and accessories, personal safety equipment, rotary table

PERFORMANCE STEPS:

1. Mount rotary table and align to spindle.
2. Mount and secure workpiece in rotary table.
3. Mount end mill in spindle chuck.
4. Calculate spindle speed.
5. Start spindle and raise work to cutter.
6. Feed to desired depth.
7. Calculate rotary table feed.
8. Engage rotary table feed and coolant flow.
9. Move milling table to engage cutter with workpiece.
   Note: Check rotation of cutter with rotation of table to ensure conventional cutting action.
10. Allow rotary table to make complete revolution before changing main table position.
11. Disengage, coolant, spindle and rotary table, when desired radius is obtained.
12. Lower table and move workpiece away from cutter.
13. Remove workpiece.
14. Deburr edges of workpiece.

ENABLING OBJECTIVES:

1. Explain relevant safety practices and procedures.
2. Identify types of milling machines.
3. Identify cutting fluids for milling.
4. Identify ferrous and non-ferrous material.
5. Explain cutting speeds and feeds.
6. Identify characteristics of end mills.
7. Differentiate between up cut and down cut.
8. Identify parts of rotary table attachment.

UNIT: 7 MILLING MACHINE

LEARNING OUTCOME:

7.16 End mill key seats in workpiece.

TASK:

7.16.1 End mill key seats in workpiece.

PERFORMANCE STANDARD:

Keyway must have smooth finish and snug fit with mating key-stock. Length of keyway must be within (plus) 0.0005" and (minus) 0.000". Center line position must be within (plus or minus) 0.005" from end of workpiece.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

End mill cutter, Machinists' Handbook, milling machine and accessories, personal safety equipment, workpiece

PERFORMANCE STEPS:

1. Determine size of keyway.
2. Identify material for selection of cutting speeds/feed.
3. Lay out keyway.
4. Secure workpiece in holding device.
5. Select, mount, and secure cutter end mill.
6. Position workpiece to cutter.
7. Secure table locks.
8. Select/set spindle speed control.
9. Select/set table feed control.
10. Engage spindle speed.
11. Start cut manually.
    a. Check alignment.
12. Engage table feed.
13. Apply coolant.
14. Cut keyway.
15. Disengage table feed.
16. Disengage spindle speed.
17. Stop coolant flow.
18. Shut off milling machine.
19. Check keyway size and fit with mating keystock.
20. Remove milling cutter.
21. Remove workpiece.
22. Deburr keyway.

ENABLING OBJECTIVES:

1. Explain relevant safety practices and procedures.

2. Identify types of milling machines.
3. Identify types, classifications and kinds of milling cutters.
4. Identify cutting fluids for milling.
5. Describe how various types of milling machines operate.
6. Identify characteristics of end mill cutter.
7. Explain cutting key slots.
8. Describe technique for cutting key seats with slot cutter.

UNIT: 7 MILLING MACHINE

LEARNING OUTCOME:

7.17 Center rotary table with spindle.

TASK:

7.17.1 Center rotary table with spindle.

PERFORMANCE STANDARD:

Vise must be aligned to milling machine head, within a tolerance of (plus or minus) 0.001" total runout.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Standard tool kit, dial indicator, milling machine and accessories, rotary table, wiggler

PERFORMANCE STEPS:

1. Clean table and slots.
2. Clean and place vise on table.
3. Turn rotating handle to align "o" mark with pointer.
4. Align vise by sight and fasten loosely to table.
5. Locate dial indicator in milling spindle.
6. Indicate to T slot on rotary table parallel to milling table.
7. Check reading at both ends of T slot.
8. Secure rotary table to milling table.
9. Mount mill wiggler in spindle.
10. Move table to position wiggler in center of rotary table.

ENABLING OBJECTIVES:

1. Explain relevant safety practices and procedures.
2. Identify types of milling machines.
3. Identify types, classifications and kinds of milling cutters.
4. Identify cutting fluids for milling.
5. Describe how various types of milling machines operate.
6. Explain setting up and reading dial indicators.
7. List application for rotary table.
8. Differentiate between rotary and indexing tables.

UNIT: 7 MILLING MACHINE

LEARNING OUTCOME:

7.18 Drill equally spaced holes on a bolt circle.

TASK:

7.18.1 Drill equally spaced holes on a bolt circle.

PERFORMANCE STANDARD:

Holes must be located according to blueprint specifications.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Blueprint, drills and centerdrill, layout workpiece, personal safety equipment, vertical milling machine and accessories, wiggler

PERFORMANCE STEPS:

1. Mount and align indexing table.
2. Mount workpiece on indexing table with one hole aligned at "o" mark.
3. Install spindle chuck with wiggler.
4. Start spindle and position first hole under wiggler and lock table.
5. Install centerdrill and drill hole.
6. Rotate indexing table by required degrees.
7. Repeat steps #5 and 6 until all holes are centerdrilled.
8. Install drill in chuck and repeat steps #5 and 6 until all holes are drilled.
9. Back workpiece away from spindle.
10. Remove workpiece and deburr if necessary.

ENABLING OBJECTIVES:

1. Explain relevant safety practices and procedures.
2. Identify types of milling machines.
3. Describe how milling machines operate.
4. Identify cutting fluids for milling.
5. Differentiate between boring and drilling.
6. Identify vises for milling machines.
7. Describe other techniques for driling holes on a bolt circle on the milling machine.

UNIT: 7 MILLING MACHINE

LEARNING OUTCOME:

7.19 Bore and counterbore hole in workpiece.

TASK:

7.19.1 Bore and counterbore hole in workpiece.

PERFORMANCE STANDARD:

Bored and/or counterbore must be within a tolerance of (minus or plus) 1/64" on fractional dimensions and (plus or minus) 0.002" on decimal dimensions, and/or within blueprint specifications.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Adjustable boring head, boring head, center punch, counter sink, dial indicator, drill, mill wiggler, vertical mill and accessories

PERFORMANCE STEPS:

1. Lay out hole location and center punch.
2. Mount workpiece on milling machine table.
3. Mount wiggler in spindle.
4. Center hole under spindle with wiggler.
5. Lock table.
6. Select and set speeds with wiggler.
7. Centerdrill workpiece.
8. Drill pilot hole.
9. Drill hole to allow for clearance for boring head.
10. Select boring head and boring tool.
11. Mount offset boring head and tool in spindle.
12. Determine amount of tool movement by adjustment screw.
13. Set milling machine speed and feed.
14. Set cutter for light cut on workpiece.
15. Start milling machine and bore workpiece.
16. Measure bored hole and adjust tool.
17. Continue steps #15-16 until workpiece bored to designated dimension.

ENABLING OBJECTIVES:

1. Explain relevant safety practices and procedures.
2. Identify types of milling machines.
3. Identify types, classifications and kinds of milling cutters.
4. Identify cutting fluids for milling.
5. Describe how various types of milling machines operate.
6. Differentiate between drilling, blind drilling, boring, and counterboring.
7. Explain sharpening procedure for boring bit.

8. Identify various techniques for holding workpiece to table.
9. Explain calculating speeds and feeds for drilling and boring operation on milling machines.

UNIT: 7 MILLING MACHINE

LEARNING OUTCOME:

7.20 Machine slots in workpiece.

TASK:

7.20.1 Machine slots in workpiece.

PERFORMANCE STANDARD:

Key slots must have smooth finish and snug fit with mating keystock. Length of keyslot must be within (+ or -) 0.010" and depth within (+ or -) 0.005 and - 0.000. Center line position must be within (+ or -) 0.005" from end of workpiece.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Milling machine, personal safety equipment, slotting attachment, slotting cutter, vernier caliper, workpiece

PERFORMANCE STEPS:

1. Mount work-holding device on mill table.
2. Identify material of workpiece.
3. Secure workpiece to table or in work-holding device.
4. Mount slotting attachment on mill.
5. Set slotting attachment at 90 degrees or required angle.
6. Position slotting attachment over table.
7. Select and mount cutter.
8. Select and adjust stroke length.
9. Align cutter to workpiece.
10. Set speed.
11. Slot to specifications.
    a. Measure workpiece after trial cut.
    b. Make adjustments as required.
12. Deburr workpiece and measure.
    a. Accept workpiece, or
    b. Reject workpiece and/or take corrective action.

ENABLING OBJECTIVES:

1. Explain relevant safety practices and procedures.
2. Identify types of milling machines.
3. Identify types, classifications, and kinds of milling cutters.

4. Identify cutting fluids for milling.
5. Describe how various types of milling machines operate.
6. Explain how to set and read vernier caliper.
7. Explain complementary angles.
8. Describe techniques for securing work to milling machine.

UNIT: 7 MILLING MACHINE

LEARNING OUTCOME:

7.21 Drill and tap holes in workpiece.

TASK:

7.21.1 Drill and tap holes in workpiece.

PERFORMANCE STANDARD:

Hole and threads must be machined to blueprint specifications.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Boring bit, drills, thread cutter bit, vertical mill with accessories, wiggle

PERFORMANCE STEPS:

1. Lay out hole location.
2. Mount workpiece on milling machine table.
3. Mount wiggles into spindle chuck.
4. Center hole under spindle with wiggler.
5. Lock table.
6. Select and set speeds and feeds.
7. Centerdrill workpiece.
8. Drill pilot hole.
   a. Use coolant as required.
9. Drill hole to diameter required for thread being cut.
10. Mount boring head in spindle.
11. Install cutter bit in boring tool holder to touch bore.
12. Set spindle speed and table feed rate.
13. Turn on coolant flow.
14. Start spindle and feed system together.
15. Stop machine when thread is cut to depth.
    Note: Do not disengage table feed.
16. Reverse drive unit and stop when tool backs out of workpiece.
17. Set tool for deeper cut and repeat steps 14-15 until full depth of thread is obtained.
18. Turn off coolant flow.
19. Back workpiece away from spindle and remove.

ENABLING OBJECTIVES:

1. Explain relevant safety practices and procedures.
2. Identify types of milling machines.
3. Identify cutting fluids for milling.
4. Explain thread forms.
5. Differentiate between drilling and boring.
6. Identify classes of thread fits.

UNIT: 7 MILLING MACHINE

LEARNING OUTCOME:

7.22 Slab mill workpiece.

TASK:

7.22.1 Slab mill workpiece.

PERFORMANCE STANDARD:

Surfaces must be smooth and flat to within .005". Dimensions of surfaces must be within tolerances of specifications.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Machinery handbook, micrometer, milling machine and accessories, personal safety equipment, slab cutter

PERFORMANCE STEPS:

1. Identify material for selection of cutting speeds and feed.
2. Select milling machine (horizontal or vertical).
3. Analyze/select approach method/set-up.
4. Mount and secure horizontal/vertical milling attachment.
5. Secure workpiece in vise.
6. Select/mount milling cutter.
7. Turn on machine.
8. Position workpiece to cutter.
9. Secure table and/or head clamps.
10. Select/set cutter speed.
11. Select/set table feed.
12. Engage cutter speed control.
13. Start cut manually.
14. Engage table feed control.
15. Apply coolant.
16. Mill horizontal/vertical surface to specifications.
17. Disengage feed control.
18. Eisengage cutter speed control.
19. Turn off coolant flow.
20. Remove workpiece from vise.

21. Turn off machine.
22. Deburr edges of workpiece.

ENABLING OBJECTIVES:

1. Explain relevant safety practices and procedures.
2. Identify types of milling machines.
3. Identify types, classifications, and kinds of milling cutters.
4. Identify cutting fluids for milling.
5. Describe how various types of milling machines operate.
6. Explain calculations of speed and feed rates.
7. Identify techniques for securing workpiece to milling machine.
8. Identify other cutters that could be used for slab work.

UNIT: 7 MILLING MACHINE

LEARNING OUTCOME:

7.23 Machine equally spaced slots using direct indexing.

TASK:

7.23.1 Machine equally spaced slots using direct indexing.

PERFORMANCE STANDARD:

Slots must be equally spaced, and machined to blueprint specifications.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Dividing head, milling machine and accessories, personal safety equipment, workpiece

PERFORMANCE STEPS:

1. Identify material of workpiece.
2. Mount and align dividing head with dial indicator and test bar.
3. Select and mount cutter.
4. Mount and align workpiece.
5. Determine number of indexes workpiece must be rotated.
   a. Dividing the number of spaces desired into 24 will give the number of holes that must be moved on index plate.
   b. Dividing the angle by 15 will give the number of holes that must be moved on index plate.
6. Set up indexing unit of dividing head.
7. Select and set up speed and feed.
8. Touch off, make primary cut, and adjust for depth of cut.

9. Measure for blueprint specifications, making necessary adjustments.
10. Recut, if necessary.,
11. Rotate indexing unit for each subsequent cut specified.
12. Inspect and measure finished part.
    a. Accept workpiece, or
    b. Reject workpiece and/or take corrective action.

ENABLING OBJECTIVES:

1. Explain relevant safety practices and procedures.
2. Identify types of milling machines.
3. Identify cutters for slotting operation on milling machine.
4. Explain set up and reading dial indicators.
5. Explain limitations of direct indexing.
6. Explain plain indexing and angular indexing procedures.
7. Identify calculating spindle speed and feed rates.

UNIT: 7 MILLING MACHINE

LEARNING OUTCOME:

7.24 Machine a hexagon workpiece using simple indexing.

TASK:

7.24.1 Machine a hexagon workpiece using simple indexing.

PERFORMANCE STANDARD:

Workpiece must be equal side hexagon shape, with flats width to blueprint specifications.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Dividing head (with simple index capability), milling cutter, milling machine and accessories, personal safety equipment

PERFORMANCE STEPS:

1. Identify material of workpiece.
2. Mount and align dividing head with dial indicator and test bar.
3. Select and mount cutter.
4. Mount and align workpiece.
5. Select speed and feeds.
6. Mill first flat to desired cutting depth.
7. Turn index crank 6 - 16/24 revolutions.
8. Mill second flat.
9. Repeat step 7 and 8 until all six flats are milled.
10. Move table to obtain depth of next cut.

11. Repeat steps 6 thru 10 until desired hex size is obtained.
12. Remove workpiece and measure finished part.

ENABLING OBJECTIVES:

1. Explain relevant safety practices and procedures.
2. Identify types of milling machines.
3. Identify coolants for milling.
4. Identify types, classifications and kinds of milling cutters.
5. Explain setting up and reading dial indicators.
6. Explain direct indexing.
7. Explain angular indexing.

UNIT: 7 MILLING MACHINE

LEARNING OUTCOME:

7.25 Drill holes to specified angles using angular indexing.

TASK:

7.25.1 Drill holes to specified angles using angular indexing.

PERFORMANCE STANDARD:

Holes must be drilled to angles specified on blueprint.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Milling machine and accessories, personal safety equipment, plain indexing dividing head, workpiece

PERFORMANCE STEPS:

1. Identify material of workpiece.
2. Mount and align dividing head with dial indicator and test bar.
3. Select and mount drill.
4. Mount and align workpiece.
5. Determine number of indexes workpiece must be rotated.
   a. Each turn of index crank rotates workpiece 1/40th of a circle.
   b. Divide the angle desired by 9.
   c. Use hole circle on index head for fractional moves.
6. Set up indexing unit.
7. Select and set speed and feed.
8. Touch and drill first hole.
9. Move calculate rotation of index crank.
10. Drill 2nd hole.
11. Repeat steps 9 and 10 until all holes are drilled.

12. Remove workpiece.
13. Inspect and measure finished part.

ENABLING OBJECTIVES:

1. Explain relevant safety practices and procedures.
2. Identify types of milling machines.
3. Identify coolants used for drilling.
4. Explain setting up and reading dial indicators.
5. Explain direct indexing.
6. Identify hole circle indexing plates.
7. Explain plain indexing/simple indexing.

UNIT: 7 MILLING MACHINE

LEARNING OUTCOME:

7.26 Machine workpiece using compound indexing.

TASK:

7.26.1 Machine workpiece using compound indexing.

PERFORMANCE STANDARD:

Workpiece must be machined to blueprint specifications.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Dividing head with accessories, Machinist's Handbook, milling cutters, milling machine and accessories, personal safety equipment

PERFORMANCE STEPS:

1. Identify material of workpiece.
2. Mount and align dividing head with dial indicator and test bar.
3. Select and mount cutter.
4. Mount and align workpiece.
5. Determine number of indexes workpiece must be rotated.
   a. Resolve into it factor number of divisions required.
   b. Random choose two circles of holes, subtract one from the other and factor difference.
   c. Places two sets of factors obtained above center line.
   d. Factor number of turns of crank required for one revolution of spindle.
   e. Factor number of holes in each of the chosen circles.
   f. Place three sets of factors below horizontal line.
      Note: If all factors above line can be canceled by those below line, two circles chosen will give

required division if not, repeat above using different hole circles.

h. Multiply factors together from below line.
Note: This gives number of holes crank must be forwarded on one hole circle and number of hoes index plate must be turned backwards on other hole circle.

6. Set up indexing unit of dividing head.
7. Select and set up speed and feed.
8. Touch off, make primary cut, and adjust for depth of cut.
9. Measure for blueprint specifications, making necessary adjustments.
10. Recut, if necessary.
11. Rotate indexing unit for each subsequent cut specified as in step 5.
12. Inspect and measure finished part.
    a. Accept workpiece, or
    b. Reject workpiece and/or take corrective action.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Explain the relevant sections of Machinery Handbook.
3. Identify types of milling machines.
4. Describe how dividing head operates.
5. Identify cutting fluids for milling.
6. Identify ferrous and non-ferrous material.
7. Describe cutters available for milling machine.
8. Explain factoring.

UNIT: 7 MILLING MACHINE

LEARNING OUTCOME:

7.27 Machine workpiece using differential indexing.

TASK:

7.27.1 Machine workpiece using differential indexing.

PERFORMANCE STANDARD:

Workpiece must be machined to blueprint specifications.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Dividing head with differential drive, Machinery's Handbook, milling cutters, milling machine and accessories, personal safety equipment

PERFORMANCE STEPS:

1. Identify material of workpiece.
2. Mount and align dividing head with dial indicator and test bar.
3. Select and mount cutter.
4. Mount and align workpiece.
5. Determine number of indexes workpiece must be rotated.
   a. Index plate must have differential gear drive system.
   b. See Machinery's Handbook for index circle and differential gear required.
6. Set up indexing unit of dividing head.
7. Select and set up speed and feed.
8. Touch off, make primary cut, and adjust for depth of cut.
9. Measure for blueprint specifications, making necessary adjustments.
10. Recut, if necessary.
11. Rotate indexing unit for each subsequent cut specified.
12. Inspect and measure finished part.
    a. Accept workpiece, or
    b. Reject workpiece and/or take corrective action.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Explain the relevant sections of Machinery's handbook.
3. Identify types of milling machine.
4. Describe how dividing head operates.
5. Identify cutting fluids for milling.
6. Identify ferrous and non-ferrous material.
7. Describe cutters available for milling machine.
8. Differentiate between direct, simple, compound, and differential indexing.

UNIT: 8 SURFACE GRINDER

LEARNING OUTCOME:

8.1 Clean, inspect, and lubricate grinder.

TASK:

8.1.1 Clean, inspect, and lubricate grinder.

PERFORMANCE STANDARD:

Machined/sliding/finished surfaces must be clean and free of grit and dirt. Oil level gauges must show "full". All grease fittings and oil points must be lubricated according to manufacturer's specifications.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Grease gun, maintenance mechanic's tool box (hand tools), manufacturer's manual, oil cans, personal safety equipment, wiping rags.

PERFORMANCE STEPS:

1. Turn off/lock out grinder power.
2. Consult manufacturer's manual for lubrication specifications/ locations.
3. Disassemble as necessary.
4. Wipe clean all machined finished surfaces.
   a. Check for wear.
5. Locate/wipe clean lubrication points/grease fittings according to manufacturer's manual.
6. Select lubricants.
7. Fill oil reservoirs.
8. Lubricate grease fittings.
9. Check oil level gauges.
10. Wipe off excess lubricants as necessary.
    a. Check for and remove grit on sliding surfaces.
11. Reassemble as necessary.
    Note: If system has automatic lubrication and feed, check to see that all lines are open before assembling.
12. Unlock power.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Identify the different types of grinders.
3. Identify the parts of a pedestal grinder and a surface grinder.
4. Describe how surface grinder functions.
5. Explain types of lubricants and their applications.
6. Explain calculation surface feed per minute.
7. Describe types and characteristics of various wheels.
8. Explain grit rating.
9. Explain ferrous and non-ferrous wheels.
10. Describe various cutting fluids and their applications.

UNIT: 8 SURFACE GRINDER

LEARNING OUTCOME:

8.2 Inspect and mount grinding wheel.

TASK:

8.2.1 Inspect and mount grinding wheel.

PERFORMANCE STANDARD:

Wheel must be mounted according to specifications of surface grind manufacture.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Standard tool kit, grinding wheel

PERFORMANCE STEPS:

1. Lock out power.
2. Clean spindle and surface of fixed flange.
3. Ring test wheel to check for damage.
4. Insert bushings.
5. Slide wheel on spindle.
   Note: Do not force.
6. Clean outer flange and slide up against wheel.
7. Check to see if flanges bear uniformly against wheel.
8. Tighten spindle nut against outer flange.
   Note: See manufacture torquing specifications.
9. Align guards and tighten in place.
10. Stand to one side, start grinder, allow to operate at full speed for one minute.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Describe types of wheels and their applications.
3. Identify how to true and dress wheel.
4. Identify types of grinders.
5. Identify parts of surface grinder.
6. Describe how surface grinder operates.
7. Identify cutting fluids for surface grinding.

UNIT: 8 SURFACE GRINDER

LEARNING OUTCOME:

8.3 True and dress grinding wheel.

TASK:

8.3.1 True and dress grinding wheel.

PERFORMANCE STANDARD:

Grinding wheel must be dressed in accordance with specifications.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Diamond point dresser, dressing tool, fixed tool post, magnetic chuck, surface grinder

PERFORMANCE STEPS:

1. Ring test wheel for cracks.
   CAUTION: REPLACE CRACKED WHEEL.
2. Select diamond point dresser.
   a. Single point or multiple point.
   b. Rotate diamond if worn.
3. Place truing tool in tool post or attachment.
4. Position diamond point dresser on magnetic chuck.
   a. Clean magnetic chuck.
   b. Position slightly to left of wheel centerline.
   c. Angle dresser about 10 degrees to left (direction of wheel rotation).
   d. Place a piece of paper under left end of dresser holder.
   e. Energize chuck.
5. Raise wheel above height of diamond.
6. Adjust table laterally to position under high point of wheel.
7. Start grinder.
   CAUTION: WEAR GOGGLES.
8. Lower wheel until it just touches diamond.
9. Feed diamond across wheel with crossfeed handle.
   a. Use medium feed for general purpose grinding.
   b. Use fast feed for fast metal removal.
   c. Use slow feed for slow metal removal but good finish.
10. Lower wheel 0.0005" for each pass until wheel is dressed to specifications.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Identify parts of a surface grinder.
3. Describe how surface grinder operates.
4. Identify types of wheels for surface grinder.
5. Describe ring test for wheel.
6. List causes of wheel damage.
7. Identify relationship of wheel diameter to spindle speed.

UNIT: 8 SURFACE GRINDER

LEARNING OUTCOME:

8.4 Grind flat, vertical, and angular surfaces.

TASK:

8.4.1 Grind flat, vertical, and angular surfaces.

PERFORMANCE STANDARD:

Surfaces must be smooth and free of burn or chatter marks. Surface must be within (+ or -) .005" of specifications.

TOOLS, RESOURCES, EQUIPMENT AND SITUATIONS(S):

Machinist's Handbook, specifications, stock to be ground, surface grinder and accessories

PERFORMANCE STEPS:

1. Identify material of workpiece for selection of grinding wheel, speeds and feed.
2. Select/mount grinding wheel.
   a. Check for cracks and loading.
   b. Dress if necessary.
3. Secure workpiece to grinder table or vise.
   Note: Use shims as necessary.
4. Set table stops.
5. Select/set feeds/speeds.
6. Start grinder wheel (rotation).
7. Position grinder wheel to workpiece.
8. Apply coolant as necessary.
9. Engage table feed or table rotation.
10. Bring workpiece to touch grinding wheel manually.
11. Grind flat surface(s).
12. Disengage wheel feed from workpiece and back wheel away.
13. Disengage table feed or table rotation.
14. Turn off coolant.
15. Stop wheel rotation.
16. Check for size to specifications.
17. Remove workpiece from grinder.
18. Check surface trueness with surface plate and dial indicator.
19. Turn off grinder.
20. Deburr workpiece if needed.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Identify parts of surface grinder.
3. Describe how surface grinder operates.
4. Describe how to true and dress wheels.
5. Identify calculating feed speed using Machinist's handbook.
6. Differentiate between ferrous and non-ferrous material and wheels.
7. Identify coolants for surface grinding.
8. Explain how to use and read micrometers.
9. Explain layout procedures.
10. Identify techniques for mounting workpiece.
11. Identify limitations of vertical face being ground.

UNIT: 8 SURFACE GRINDER

LEARNING OUTCOME:

8.5 Grind a slot in workpiece.

TASK:

8.5.1 Grind a slot in workpiece.

PERFORMANCE STANDARD:

Slot must be smooth and free of burn or chatter marks. Surface must be within (+ or -) .005" of specifications.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Formed wheel, Machinist's Handbook, specifications, surface grinder and accessories

PERFORMANCE STEPS:

1. Identify material of workpiece for selecting grinding wheel, speeds, and feed.
2. Select/mount grinding wheel.
   a. Check for cracks and loading.
3. Secure workpiece to grinding table or vise.
4. Set table stops.
5. Select/set feeds/speeds.
6. Start grinder wheel.
7. Position grinding wheel to workpiece.
8. Apply coolant as necessary.
9. Engage table feed.
10. Bring workpiece to touch grinding wheel manually.
11. Take light cuts with automatic feeds.
12. Turn off, stop wheel rotations and check alignment.
13. Turn on power and continue passes until desired depth is obtained.
14. Turn off grinder, coolant and stop wheel rotation.
15. Check for size to specifications.
16. Remove workpiece.
17. Deburr workpiece if necessary.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Identify parts of surface grinder.
3. Describe how surface grinder operates.
4. Describe how to dress a wheel ton form reverse image shaped wheel.
5. Identify calculating feed speeds using Machinist's Handbook.
6. Differentiate between ferrous and non-ferrous material.

7. Identify coolants for surface grinding.
8. Explain layout procedure.
9. Identify techniques for mounting workpiece.

UNIT: 8 SURFACE GRINDER

LEARNING OUTCOME:

8.6 Grind workpiece square and parallel.

TASK:

8.6.1 Grind workpiece square and parallel

PERFORMANCE STANDARD:

Four sides must be squared to a tolerance of (+ or -) 30 minutes, and to a tolerance of (+ or -) 0.002" on decimal dimension, (+ or -) 1/64" on fraction dimensions, and/or to blueprint specifications.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Standard tool kit, magnet chuck, micrometer, surface grinder and accessories

PERFORMANCE STEPS:

1. Select, inspect and install wheel on surface grinder.
2. Replace all guards before starting grinder.
   CAUTION: ALWAYS WEAR EYE PROTECTION.
   KEEP HANDS CLEAR OF RUNNING WHEEL.
   TURN MAGNET ON BEFORE USING WHEEL.
   USE GUARDS AROUND WHEEL.
3. Place diamond dresser on chuck and dress wheel
   CAUTION: WEAR GOGGLES.
4. Clean chuck and place workpiece on it making sure that space between wheel and chuck is sufficient to clear workpiece.
5. Carefully lower wheel until it just touches workpiece at its highest point.
6. Move workpiece out of path of wheel and lower wheel for desired cut.
7. Start flow of coolant, if necessary, and complete cut.
8. Grind until first surface is "cleaned up".
   Note: Care should be taken here to make sure enough material is left to allow opposite side to be finished and still hold required size.
9. Grind second surface at 90 degree angle to first:
   a. Clean chuck and place angle plate on it.
   b. Secure first surface of workpiece to vertical surface of angle plate holding it with C clamps.

c. Make sure that workpiece is higher than top of angle plate or any part of C clamp, then proceed as in steps 5-8 from above.

10. Finish surface #3:
    a. Clean chuck and place workpiece on it with surface #1 down.
    b. Repeat steps 4 and 5 until required dimension is reached.
11. Finish surface #4:
    a. Repeat step 10 with surface #2 down.
12. Measure workpiece.
    a. Accept workpiece, or
    b. Reject workpiece and/or take corrective action.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Identify parts of surface grinder.
3. Describe how surface grinder operates.
4. Describe how to true and dress wheel.
5. Identify calculating feed speed using Machinist's handbook.
6. Differentiate between ferrous and non-ferrous material and wheels.
7. Identify coolants for surface grinding.
8. Explain how to use and read micrometer.
9. Explain layout procedures.
10. Identify techniques for mounting workpiece.

UNIT: 8 SURFACE GRINDER

LEARNING OUTCOME:

8.7 Dress angle on wheel.

TASK:

8 7.1 Dress angle on wheel.

PERFORMANCE STANDARD:

Wheel must be ground to specified angle without valleys or ridges.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Diamond point dresser, grinding wheel, radius/angle dresser, surface grinder and accessories

PERFORMANCE STEPS:

1. Ring test wheel for cracks.
   CAUTION: REPLACE CRACKED WHEEL.

2. Mount radius/angle dresser with bit to table.
3. Set dresser for angel operation.
4. Position centerline of diamond point with center line of spindle.
5. Lock the grinding table.
6. Adjust micrometer base-lead screw until diamond touches wheel.
7. Turn angle dressing handle to move diamond across wheel at desired angle taking .002.
8. Feed diamond cutter in .002 and repeat cut.
9. Repeat steps 7 and 8 until wheel is faced to desired angle.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Identify ferrous and non-ferrous wheels.
3. Identify grits and shapes of wheels.
4. Identify grinding wheel markings.
5. Identify parts of surface grinder.
6. Describe mount wheels.
7. Explain how surface grinder operates.
8. Explain reverse angle and negative profile.
9. Identify types and applications of dress tools.

UNIT: 8 SURFACE GRINDER

LEARNING OUTCOME:

8.8 Grind an outside diameter.

TASK:

8.8.1 Grind an outside diameter.

PERFORMANCE STANDARD:

Surface must be smooth and free of burn or chatter marks. Cylindrical surface must be within tolerance of specifications with T.I.R. (total inch runout) not to exceed .001".

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Cylindrical grinder, dial indicator, diamond wheel dresser, drive dog, grinding machine manual, outside micrometer, personal safety equipment

PERFORMANCE STEPS:

1. Identify material for grinding speeds and feed.
2. Select/mount wheel.
   a. Dress if necessary.

3. Attach drive dog to cylindrical workpiece.
   a. Check for lightness.
4. Lubricate center.
5. Determine length of area to be ground.
6. Align workpiece in grinder.
7. Set stops for length.
8. Turn on power (main control).
9. Determine/set speed of wheel.
10. Determine/set speed of cylindrical workpiece.
11. Determine/set feed rate for longitudinal travel.
12. Check grinding wheel for cracks, loading, etc.
    a. Dress, replace, if necessary.
13. Start wheel (rotation).
14. Start cylindrical workpiece (rotation).
15. Position wheel to cylindrical workpiece.
16. Apply coolant as necessary.
17. Engage longitudinal travel feed.
18. Bring wheel to workpiece slowly.
19. Grind cylindrical workpiece.
20. Back wheel away from cylindrical workpiece.
21. Disengage longitudinal travel feed.
22. Turn off control for cylindrical workpiece (rotation).
23. Turn off wheel rotation control.
24. Turn off coolant.
25. Check measurements of workpiece.
26. Stop grinder.
27. Remove workpiece.
28. Remove drive dog from cylindrical workpiece.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Identify ferrous and non-ferrous material.
3. Identify parts of cylindrical grinder.
4. Describe how cylindrical grinder operates.
5. Explain how to mount, true and dress wheels on cylindrical grinder.
6. Explain calculating speed and feed setting on cylindrical micrometers.
7. Explain reading micrometers.
8. Identify coolant fluids for grinding operation.
9. Identify wheels number markings.
10. Identify type of wheels and their application.

UNIT: 9 SPECIAL MILLING PROCESSES

LEARNING OUTCOME:

9.1 Machine a spur gear and/or worm gear.

TASK(S):

9.1.1 Machine a spur gear.
9.1.2 Machine a worm gear.

TASK:

9.1.1 Machine a spur gear.

PERFORMANCE STANDARD:

Spur gear must be machined to blueprint specifications.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Dividing head for milling machine, milling machine and accessories, personal safety equipment, rotary table for milling machine, workpiece - gear blank

PERFORMANCE STEPS:

1. Identify material of workpiece.
2. Mount and align rotary table to mill.
3. Secure workpiece to rotary table.
4. Calculate speed and feed.
5. Drill and bore center hole of spur gear.
6. Remount workpiece on rotary table using bored center hole.
7. Calculate speed and feed.
8. Mill outside radius of blank using rotary table feed and appropriate cutter.
9. Mount and align dividing head and tail stock.
10. Mount workpiece on shaft between centers of dividing head and tail stock.
11. Select milling cutter for gear teeth.
12. Calculate speed and feed.
13. Calculate index head movement.
14. Mill teeth on blank using indexing head.
15. Remove work and measure finished part.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Identify types of milling machines.
3. Identify types, classifications and kinds of milling cutters.
4. Identify cutting fluids for milling.
5. Describe aligning rotary table, dividing head.
6. Identify techniques for securing workpiece to milling machines.
7. Explain simple indexing, direct indexing and angular indexing.

UNIT: 9 SPECIAL MILLING PROCESSES

LEARNING OUTCOME:

9.1 Machine a spur gear and/or worm gear.

TASK:

9.1.2 Machine a worm gear.

PERFORMANCE STANDARD:

Worm gear must be machined to blueprint specifications.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Dividing head with drive mechanism, lathe, milling machine and accessories, personal safety equipment, workpiece

PERFORMANCE STEPS:

1. Identify material of workpiece.
2. Mount workpiece in lathe chuck.
3. Face and center drill both ends.
4. Turn workpiece between centers on lathe to desired diameter.
5. Mount and align dividing head with power drive and tail stock to milling table.
6. Mount workpiece between center.
7. Mount and align cutter to workpiece.
8. Calculate spindle speed, table feed, and dividing head feed speed.
9. Touch workpiece to cutter and make light pass to check alignment.
10. Set to desired depth of cut.
11. Turn on coolant flow.
12. Mill workpiece using automatic feed system.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Identify types of milling machines.
3. Describe attachments available for milling machines.
4. Identify coolant/cutting fluids for milling.
5. Identify parts of lathe.
6. Explain calculation speeds and feeds for milling machines and lathes.
7. Explain plain indexing, simple indexing, direct indexing and angular indexing.

UNIT: 9 SPECIAL MILLING PROCESSES

LEARNING OUTCOME:

9.2 Cut a sprocket.

TASK:

9.2.1 Cut a sprocket.

PERFORMANCE STANDARD:

Sprocket must be cut to blueprint specifications.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Dividing head for milling machine, lathe and accessories, Machinery's Handbook, milling machine and accessories, personal safety equipment, sprocket cutter, workpiece - circular blank.

PERFORMANCE STEPS:

1. Identify material of workpiece.
2. Mount workpiece in lathe chuck.
3. Center drill, drill and bore hole for sprocket shaft.
4. Calculate speed and feed rate.
5. Face workpiece.
6. Mount on lathe using bored center hole.
7. Face and turn to outside diameter specified.
8. Mount and align divider head and tail stock on milling table with dial indicator and test bar.
9. Select and mount sprocket cutter on milling machine arbor/ spindle.
10. Mount workpiece in dividing head.
11. Calculate speeds, feed, and index movement.
12. Touch off first tooth with cutter (check alignment).
13. Mill first to depth.
14. Rotate index crank require holes.
15. Mill next tooth.
16. Repeat step 14 and 15 until all sprocket teeth are formed.
17. Back workpiece away from cutter.
18. Remove workpiece and check measurements.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Explain the relevant sections of Machinery's Handbook.
3. Identify types of milling machine.
4. Describe how dividing head operates.
5. Identify cutting fluids for milling.
6. Identify ferrous and non-ferrous material.
7. Describe cutters available for milling machine.

8. Differentiate between direct simple, compound, and differential indexing.

UNIT: 9 SPECIAL MILLING PROCESSES

LEARNING OUTCOME:

9.3 Machine a spline using index head.

TASK:

9.3.1 Machine a spline using index head.

PERFORMANCE STANDARD:

Spline must be machined to blueprint specifications.

TOOLS, RESOURCES, EQUIPMENT AND SITUATIONS(S):

Index head, milling machine and accessories, personal safety equipment, spine cutter, workpiece

PERFORMANCE STEPS:

1. Identify material of workpiece.
2. Mount and align index head to milling machine.
3. Mount workpiece in index head.
4. Mount spline cutter in milling machine.
5. Calculate speed and feed rate.
6. Touch cutter to workpiece.
7. Mill first spline and back out of cut.
8. Rotate workpiece with index head.
9. Mill next spline and back out of cut.
10. Repeat steps 8 and 9 until all splines are milled.
11. Back away workpiece.
12. Remove and measure workpiece.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Identify types of milling machines.
3. Identify types, classifications and kinds of milling cutters.
4. Identify cutting fluids for milling.
5. Explain dividing heads.
6. Identify attachments for milling machines.
7. Describe characteristics of spline cutter.
8. Identify various techniques for holding workpiece to table.
9. Explain calculating speeds and feeds for drilling and boring operation on milling machines.

MACHINE SHOP
STANDARD TOOL KIT

Calipers, inside
Calipers, outside
Calipers, vernier
Chisels, assorted, steel cold
flat
Dial indicators
Feeler gauges (set)
Files, assorted
Flashlight, safety, 2 cell
Hacksaw
Hammer, ball peen
Hammer, chipping
Mallet, rubber
measuring
Micrometer, depth
Micrometer, external 1"
Micrometer, internal
Micrometer, telescoping
Pliers, needlenose
Pliers, regular
Pliers, side cutter
Punches, center, set of 4
Punches, pin, set of 4
Scale, 6" steel
Screwdrivers, assorted,
Screwdrivers, Phillips
assorted
Screw extractor set
Scribes
Straightedge 1/4"x1"x24"
Spirit level
Square, combination
Tags, safety
Tape, 10 foot steel
Vise grips
Wrenches, allen assorted
Wrenches, hex box/open
end, 1/4"-1"
Wrenches, adjustable 6"-12"
Wrenches, pipe, 6"-12"
Wrenches, socket, 3/8" drive
Wrenches, socket, 1/2" drive

Maintenance Mechanic's Personal Safety Equipment (PSE)

Gloves
Hard hat
Safety glasses
Safety toe shoes